Spring 1970

South Dakota Farm & Home Research

Agricultural Experiment Station, South Dakota State University

Vol. XXI Spring 1970 No. 2

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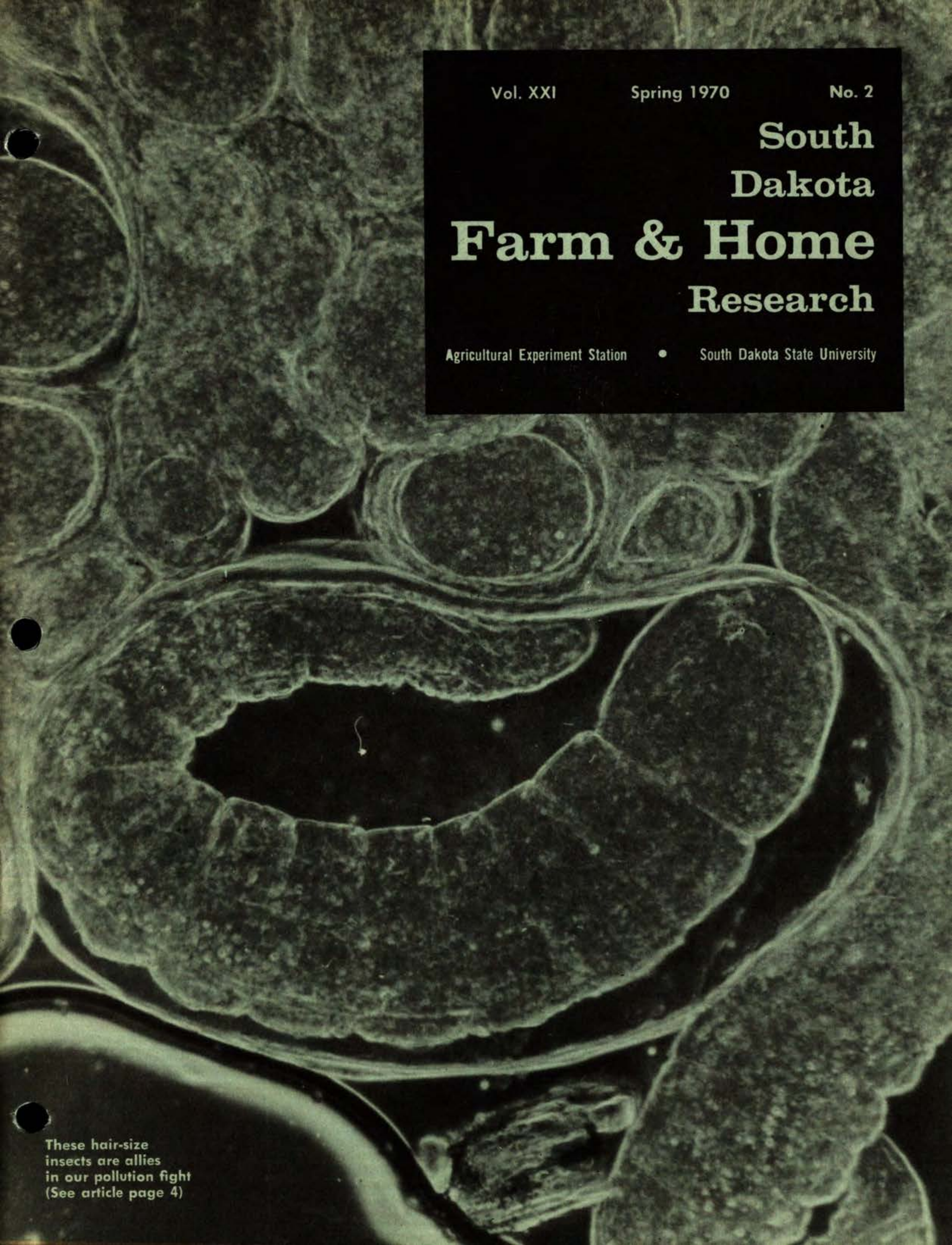

These hair-size insects are allies in our pollution fight (See article page 4)

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Additional Dutch Elm Disease Research	DDT ban means other methods are needed for control of the serious shade tree disease.
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PHOTO CREDITS:

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From the Dean and Director . . .

This vast complex of pollution control and how to meet it poses problems vital to life itself, problems much more difficult to solve than landing a man on the moon, problems so costly that funds spent in waging war seem small in comparison.

We have the choice of finding a delicate balance between the position of extinction if we do nothing or not enough, and bankruptcy if what we do is misdirected or mishandled. Another problem is that we all tend to point to the other guy and say he is at fault or unless he does his part I won't either. We must realize, and soon, that man brought this situation upon himself and there is no time, no reason, no possibility of bickering about who did it, who first discovered we're in a jam, or who should be the knight in shining armor who leads us out.

We must also remain rational people who seek knowledge, and who do not panic.

However, there are solutions available right now and more are in store for the future.

Let's look at it this way:

Available Information

We've got a storehouse of information that can be applied to prevention and control of pollution. We've got to sort out what can be used, where it can be used, and then through educational programs get this information out so people can and will use it. At South Dakota State University in the Agricultural Experiment Station and the Engineering Experiment Station we have talent and facilities to continue to do research leading to additional methods of improving our environment.

There is another source of information for the future that we must not overlook. In some classroom or laboratory—not on the street—at SDSU today sits a student who—perhaps unknowingly—is forming solutions to pollution problems and with further training and development will have them available in the not-too-distant future. This student may be in a soils laboratory, a chemistry laboratory, an engineering class, working with an animal scientist, designing machinery in a mechanized agriculture class, studying insects, be in a psychology class or studying sociology or economics, perhaps there's a budding journalist who someday will provide the communication link between technical scientific research and the ultimate user in urban or rural area.

Long-Term Concern

We must keep in mind that this pollution and environment concern is not just a "right-now" thing. It will continue, possibly at an accelerated pace, and even bring up undreamed of problems that must be solved. That is the reason we must keep our educational process in top-notch working order. We must provide the proper facilities, the trained talent to teach and instruct, and the vigorous encouragement and inspiration that young men and women need as they prepare for a career.

Research alone is not the complete answer for successful pollution prevention and control. We need a continuous crop of new ideas and new methods that only the younger generation can provide through adequate training and education. □

Duane Acker

Education and Pollution Control

Published quarterly by the Agricultural Experiment Station, South Dakota State University, Brookings, South Dakota. This publication will be sent free to any resident of South Dakota in response to a written request.

A Report of Progress

Vol XXI Spring 1970 No. 2

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South Dakota
Farm & Home
Research

SERVING THE PEOPLE OF SOUTH DAKOTA THROUGH TEACHING, RESEARCH, EXTENSION

A South Dakota State University report:

If insecticides are pollutants . . .
. . . who's doing what about them?

Life May Be Worse for Some Costly South Dakota Insects

Robert J. Walstrom, head of the SDSU entomology-zoology department shows shipping containers in which parasites of alfalfa weevil were sent to South Dakota from New Jersey. The parasites were released in western South Dakota.

You look for the weakest links when you want to know the strength of a length of chain.

Entomologists, devising insect control methods that can be used in South Dakota, use the same idea when they study the interlocking sequence of events marking the lives and loves of insects. In this study of insect habits, weaknesses often turn up which can be exploited to work to the disadvantage or destruction of the pest species. But exploiting these weaknesses and fitting them into a cropping practice, for instance, is like putting together the pieces of a jigsaw puzzle.

State and federal entomologists in South Dakota are working at these jigsaw puzzles as they concern nonchemical controls in no less than nine destructive insects which cost the state's crop and livestock producers millions of dollars annually. The work is done by the federal Northern Grain Insects Research Laboratory at Brookings and the South Dakota Agricultural Experiment Station at South Dakota State University.

Life cycle studies may detect a weakness such as susceptibility to attack by other insects or diseases, it may be weather, even plain old sex – a myriad of possibilities exist. One of the most common ways of exploiting an insect weakness is to spray or spread or paint certain kinds of poison chemicals in places where insects appear. These, too, are critical as to time of application, placement of application and effectiveness. Use of chemicals is fine if it doesn't go too far. But man is finding out that his environment is affected by some—not all—of the same chemicals he's using against the insects.

Non-Chemical Controls Needed

Does this mean we'll discard or ban every insecticide? Not at all, say entomologists, because they will continue to be necessary and safe if used properly. It does, however, emphasize the need for finding additional non-chemical controls. Even a measure of success in finding them could lessen, but not eliminate, the use of pesticides that pollute the environment.

You may be surprised to learn, too, that this non-chemical control idea isn't new. Almost a century before pollution suddenly became a 9-letter dirty word, scientists looked for biological control-type help in the battle against insects. In the late 1960's over half of the money spent by the Entomology Research Division of USDA research was for insect biology and alternate insect control methods and only 16% directly for insecticides and residues.

Pitting beneficial insects against injurious forms of insects is only one of several non-chemical methods entomologists use in the complex system termed "biological controls." Lining up beneficial insects to attack pest insects in a field crop is a tough job. For example, not every damaging insect in South Dakota has a known potential six-legged enemy right now. If none can be "imported" from some other part of the planet, entomologists look to other, often devious, control methods.

Besides insect enemies, the non-chemical attack may also employ insect-resistant crops, attractants, sterility methods, crop culture methods, and insect diseases. Integrated control is a means which combines biological or other controls with more specific and precise use of chemicals.

Insect Against Insect

Last spring SDSU entomologists introduced two new "imported" species of insect enemies of alfalfa weevil in western South Dakota to join another resident species. These three tiny beneficial wasp-like insects are harmless to crops and animals but they go after alfalfa weevils. The new ones, of European origin, came to South Dakota via the USDA New Jersey parasite introduction laboratory. How they adjust to South Dakota conditions can only be determined by surveillance and assessment in the next few years.

The costly greenbug, an aphid, is under scrutiny in South Dakota mainly because of damage to wheat and sorghum.

The greenbug menace leads to studies at the federal lab about movement of beneficial greenbug-predator ladybird beetles from one area to another and from one crop to another. As more is learned about the various species of ladybird beetles and such allies as lacewings and damsel flies in South Dakota, hopefully ways will be devised to increase the abundance and effectiveness of these aphid-eaters for a concentrated attack. Crop management might be the key. For instance, preliminary findings indicate that alfalfa fields may be a primary reservoir for these insect predator populations. Thus, cutting dates and chemical treatments of alfalfa may have decided effects on these friendly insects on grain crops.

Meanwhile, some greenbug parasites tiny enough to live inside their hosts spent last winter in fall-like temperatures in laboratory growth chambers at SDSU. Life cycle of these aphid parasites is being studied to see if man can assist them in building up their numbers.

Different aphids are also common on other plants and unless control factors are working you'll see, for example, elm trees dripping a gooey, sticky stuff called honeydew caused by feeding aphids.

Integrated Controls

Generally a pest reaches outbreak numbers followed by a peak build up of its enemies. In other words, the fire is frequently in high blaze before the firemen arrive. If predators or parasites can be introduced in mass at the right time to diminish the time lag, they'd be of more help. Another approach is "integrated" use of specific insecticides to blunt the build up of destructive insects so the tougher "good guys" can clean up the job. Investigations have determined that some of the predators are less susceptible to certain insecticides than the insects upon which they prey. Integrated control involves timely application of insecticides in carefully controlled amounts — undoubtedly something many insecticide users should have been doing all along.

SDSU entomologists are also assessing how biological controls can be tied in with other methods to help prevent losses caused by face flies and stable flies in livestock. Right now this is mainly concerned with effects of natural insect predators on immature forms of the fly pests found in cattle dung and other development areas at various times of the year.

Corn Rootworm Controls

Western corn rootworm, the most damaging type — and perhaps the most studied — in South Dakota, spends its winter in a resting or diapause stage as an egg. This is a potentially weak link or vulnerable stage because of its duration and the winter temperature extremes. Federal entomologists are interested in basic research to study differences in eggs of western corn rootworm and those of the southern corn rootworm, which can't overwin-

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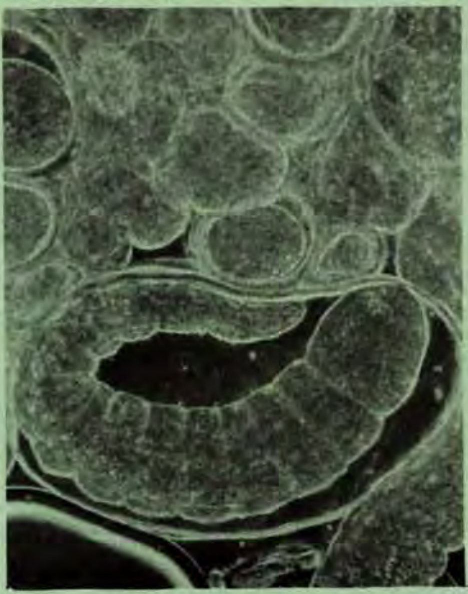


A microscopic view of a mass of developing embryos of a parasite in an army cutworm larva. The worm-like specimen is in a later stage of development than the circular-appearing specimens. These parasites will grow into adult wasps and emerge from the dead larva as shown in another photo with this article. (Photo: Northern Grain Insects Research Laboratory.)

ter in this area. The egg study might throw light on a factor associated with diapause that could be manipulated to cause self destruction of the western variety when it lays eggs in South Dakota. If in the western species this diapause stage can be interrupted chemically or mechanically a control method might result.

The corn rootworm is facing the possibility of corn lines that are tolerant to attack — they fight back. Currently this mainly concerns a plant that can tolerate an attack on its roots and then make a growth comeback — a line of corn that has greater root-producing capabilities. Hundreds of inbred lines have been evaluated for resistance by state and federal entomologists in cooperation with plant breeders throughout the Midwest. One of the better sources of tolerance was found in the SDSU plant science department germ plasm stock and released for plant breeder use in corn improvement. If what rootworms don't like in some near relatives of corn can be genetically transferred to corn, you've got a good means of non-chemical control right there.

Ground Beetles Beneficial?

Scores of species of ground beetles have been identified in a "trap route" from White to Sioux Falls and looping back to Brookings. These surveys give entomologists an idea about abundance and relative activity of these insects. It has been found that certain cropping practices and especially soil types are conducive to a given species of ground beetle. After life cycle studies help determine just how beneficial some of these ground beetles actually are, crop management may eventually become a feasible method to help build up South Dakota populations.

Agricultural Experiment Station entomologists study the European corn borer as a pest which may be partially controlled by insect parasites imported into South Dakota several years ago. Up to 6% parasitism has been observed in borer populations.

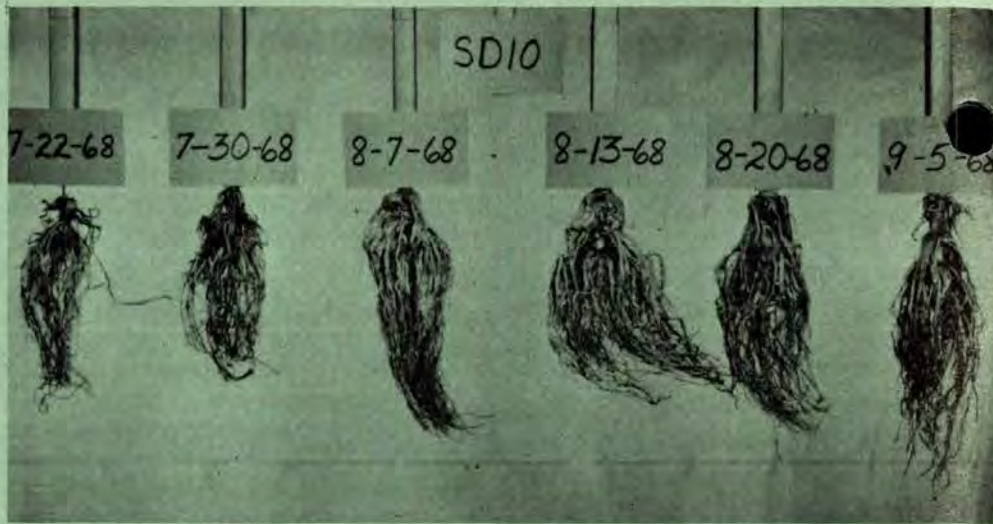
Another phase of biological control in which insects are set out against weeds will be investigated in South Dakota starting this spring. The South Dakota Wheat Commission has provided financial support for Agricultural Experiment Station research into possibilities of importing at least two insects which feed on Canada thistle and bull thistle. One of these insects, to be introduced into the United States for the first time in 1970, originates in France.

Armyworms, Army Cutworms

Remember that 1969 armyworm outbreak? Quick work by entomologists with the aid of insecticides saved millions of dollars in crop damage. Also learned was that up to 15% of larvae collected from fields were parasitized. The biology of these parasites is being studied by federal entomologists using insects reared in the laboratory.

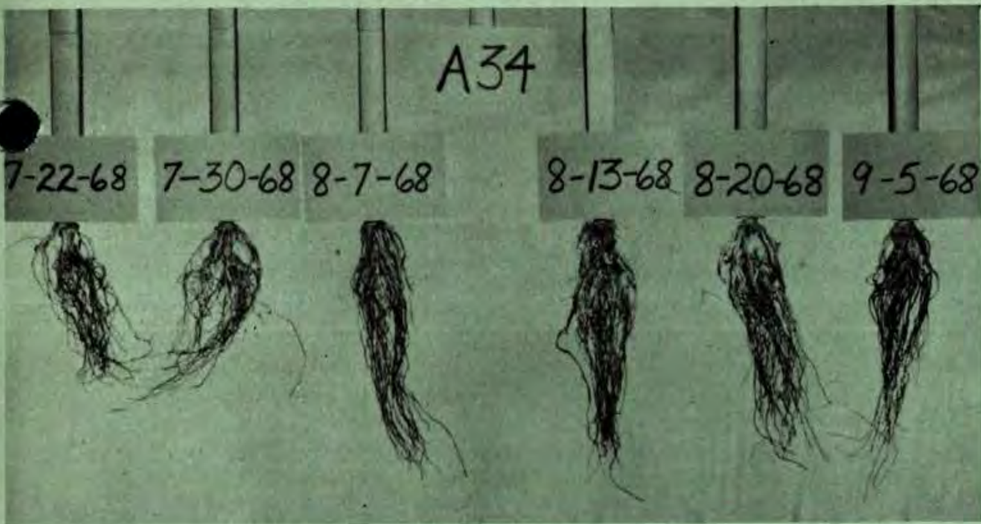
The army cutworm — different from the armyworm — was a problem in western South Dakota wheat in 1968. Army cutworms from Nebraska and Colorado spend hot summer months in the cool Rocky Mountains, returning to the plains in the fall to lay eggs and cause damage in wheat and alfalfa fields. The Northern Grain Insects Research Laboratory has set out a series of light traps to determine if the Black Hills afford a summer respite for South Dakota army cutworm moths. If so, it might offer a place of attack where the insect has concentrated.

About two dozen light traps are used in this study which is aided by cooperation of county Extension agents, vo-ag teachers, farmers and Forestry Service personnel. This study may also afford a base for predicting when and where army cutworm infestations are likely



Root development over the growing season of two experimental inbred corn lines showing good rooting (left) and poor rooting (right). The inbred SD10, from the South Dakota Agricultural Experiment Station, is an example of development of a parent line with tolerance to corn rootworm damage. Such

This is the type of light trap being used in western South Dakota to study army cutworms. Insects are attracted by the light, strike the baffles and fall in the bucket where they are killed with insecticide.



inbreds are used by plant breeders and seed companies to produce hybrids which are sold commercially. Numbers on each root system indicate the date on which that system was removed from soil. (Photo Northern Grain Insects Research Laboratory.)

These poles (above) with sticky drums are used in studies about movement of beneficial ladybird beetles from one area or crop to another. The close-up (below) shows insects trapped on a drum.

to occur, thus establishing a warning system of use to the farmer.

Additionally, research entomologists are studying army cutworm parasites. In the case of one kind of wasp-like parasite, more than 2,000 individuals were recovered from just one army cutworm larva. Parasitism in the field has been observed as high as 80%.

Insects Have Diseases Too

Insects have their own disease problems, too. Several viruses isolated from cutworms are now being investigated following development of an artificial method of producing enough cutworms in the lab at Brookings to have a supply of host specimens. Other bacterial and fungal disease organisms are also being studied for possible introduction under South Dakota conditions. One host researchers are eyeing is the European corn borer.

In at least one case, entomologists are turning to host plant resistance to a destructive insect as the most practical means of control. In South Dakota, one example involves the wheat stem maggot which in the larval stage causes losses every year. The most conspicuous injury in wheat is appearance of apparently ripened white heads during the time kernels are forming in the green unripened grain. Entomologists have rated the resistance of several spring wheats grown in South Dakota based on differences in infestation of wheat stem maggot. Germ plasm of the most promising varieties tested has been retained for use by plant breeders.

Farmers themselves have and are using a biological control method for corn rootworm. This consists of rotations that help reduce corn rootworm populations. The reason a rotation program helps is that rootworm larvae may have a very high survival rate when continuous corn is grown. A rotation may not be the complete answer, however, because corn rootworm larvae can also survive at very low levels on other plants—wheat and foxtail, for instance. Breaking the corn-after-corn sequence does assist in bringing rootworm population levels down to a point where other factors—chemicals or tolerant hybrids, for example—become more effective. Sorghum roots are toxic to larvae of the corn rootworm due to the cyanid content and therefore can be used safely in a rotation.□

ALLIES IN THE POLLUTION BATTLE

In case you want to do some name-dropping, here are a few potential allies in the South Dakota effort for improvement of environment, or the pollution battle:

Microctonus aethiops (Ness). A wasp-like parasite of the alfalfa weevil

(Continued, next page)

Hundreds of these parasites (above) have been counted as emerging from single larva of army cutworms—one count going up to 2,000. Spots on the larva (at top) show emergence holes for the parasites, a tiny wasp-like insect. Army cutworms caused damage in western South Dakota wheat in 1968. (Photo: Northern Grain Insects Research Laboratory.)

released in the St. Onge and Spearfish areas in 1969. Living inside the adult weevil, it virtually castrates its host thereby preventing normal reproduction. Parasitized female weevils stop laying eggs. Although the wasps do not directly attack the host's reproductive system they probably rob the weevil of nutrients needed for normal development of reproductive organs. This parasite, if successfully established, would do the most good in early spring.

Tetrastichus incertus Ratzburg. Another wasp-like insect enemy of alfalfa weevil also obtained from New Jersey and released in the northern Black Hills area in 1969. This parasite does its damage to alfalfa weevil hosts later than *Microctonus aethiops* and continues active for a longer time. It kills the host weevil larvae in their cocoons.

Bathyplectes anurus (Thomson). This was a third species of small wasp imported from New Jersey for release in South Dakota last year. This one was not released, however, as all specimens in the shipping container were dead upon arrival during a late spring snowstorm. It attacks the larval stage of the alfalfa weevil.

Bathyplectes curculionis. This is still another wasp-like parasite which illustrates that any one species of parasite cannot alone be expected to eliminate alfalfa weevil. It has been found in western South Dakota almost from the time alfalfa weevil was first reported in the area — obviously indicating it needs help from other parasites or from man if losses from alfalfa weevil are to be substantially reduced.

Lysiphlebus testaceipes (Cress). This greenbug parasite is being studied in SDSU laboratories. As described by USDA: ". . . a useful and readily observed parasite . . . slender but industrious little insect that destroys millions of aphids. It becomes very active on sunny days. Then it scurries about among the aphids on a leaf and stops here and there to tap an aphid with its antennae. Afterwards, it thrusts its ovipositor into the aphid with a quick motion and deposits an egg within. The aphid shows no ill effects for about 3 days, when it stops reproducing. Soon the rapidly developing parasite larva (inside) devours the vital organs of the aphid."

Sympiesis viridula. This is a parasite of European corn borer released in South Dakota several years ago. In 1966, for instance, 6% parasitism in corn borer populations was attributed to this insect.

Ceutorhynchus litura. A weevil that feeds on Canada thistle and bull thistle which is being introduced into the U. S. from Europe for the first time this year. Specimens of this insect will be released this spring in South Dakota.

Altica carduorum. A flea beetle that feeds on thistles will be released in South Dakota for the first time this year although it has been introduced elsewhere in the U. S. and Canada previously.

Bacillus thuringiensis. A disease organism affecting a number of insect pests and also considered an excellent biological control organism. South Dakota studies by federal entomologists currently seek insecticides which might be compatible to use in conjunction with this possible biological control. Main potential victims: European corn borer and certain cutworms.

Copiodosoma bakeri. A polyembryonic hymenopterous parasite of the army cutworm. Over 2,000 parasites can be produced from a single host. Rate of parasitism in the field has been as high as 80%.

Amblyteles sp. Another hymenopterous parasite of the army cutworm. Field collected larvae have been parasitized up to 75% by this parasite.

Hippodamia convergens. This is the well-known common lady beetle which is a predator of aphids.

Chrysopa spp. Another aphid predator with most damage being done by the larvae. The adult stage is known as the lacewing.

Dendrocopus villosus and *Dendrocopus pubescens.* These should not be forgotten in listing man's allies in control of insects by non-chemical means. They are the hairy woodpecker and the downy woodpecker which have been observed removing European corn borer larvae and egg masses from corn plants—in the winter from dead cornstalks.□

Insects are reared by the thousands to provide the numbers needed in a research laboratory. These pale western cutworm larvae reared from eggs are being transferred to individual plastic cup-like containers in which they will continue to grow to the adult stage. Previously insects were fed plant materials but now a special diet or "ration" has been developed for them. This photo was taken at the Northern Grain Insects Research Laboratory in early March.

A South Dakota State University report:

If soil erosion is biggest polluter . . .
. . . who's doing what about it?

It's WHEN We Begin to Fight Pollution

We already know how to reduce South Dakota's major agricultural pollution problem by 75%, says a South Dakota State University agronomist, but the big question is: Will we voluntarily take the huge action step soon enough to forestall being forced to do so by law or even just to survive?

It's going to cost a lot whatever we do about pollution – either standing around in final handwringing defeat or rolling up our sleeves and taking effective action, says L. O. Fine, an agronomist who has been associated with agricultural research in South Dakota for 24 years. There are compensations, however. They can be measured in our compatibility with our environment or even in dollars and cents as, for example, when pollution control means more efficient use of farming inputs or of natural resources.

"If I were asked to rate the three top agricultural sources of pollution in the state, I would assign 88% to soil erosion, 11% to livestock operations, and 1% to fertilizer and pesticides," he declares. The same top-rank for runoff and topsoil erosion is given by many scientists evaluating the nation's major sources of agricultural pollution.

Ways to Cut Erosion

Six major points (see accompanying box) are advocated by Dr. Fine to help reduce the soil erosion problem and he adds six more to aid in preventing another potential pollution source – fertilizers – from becoming acute. He believes the blame assigned to fertilizers as a major pollution cause is unjustified and results from what he terms irresponsible public reporting.

Developments are shaping up fast, he adds, citing instances where government controls to reduce or prevent pollution are already apparent. These have been a way of life in some Scandinavian countries. Hawaii's laws relating to land treatment to control sediment in waters give ultimate authority to determine adequacy of conservation measures to the local health officer. Nearer home, the Iowa House of Representatives passed legislation to give a government board authority to determine where, when and how much pesticide and fertilizer may be used on land.

"The next step – nationally, locally or both – may well be rural land use zoning and conservation by force," Dr. Fine declares. "Perhaps it should come even before strict chemical legislation."

"You hear the contention that we've been practicing soil erosion control and conservation for years, that apparently it hasn't helped much as evidenced by current pollution problems. The point is that these conservation practices have helped. That's where we've gained a lot of our knowledge. But these practices have been applied on a comparatively small scale, mainly on a voluntary basis, or too often merely neglected.

Fertilizers a Factor

"With respect to environment, fertilizers will become an increasing factor with which to reckon, but their impact can be kept minor by judicious use and the advent of slow-release compounds as well as other technology. Nationally, fertilizer use is climbing but now at a much slower rate than in South Dakota. In this state intensive use of fertilizer is just getting started but is still only a fraction of that used by our neighboring states on major crops such as corn and wheat (see Tables 1 and 2).

"The use of fertilizer nitrogen in the United States (5 million tons per year) accounts for 5.62 pounds of the 38 pounds of nitrogen consumed per capita per year – and this is deemed by many a bare subsistence average protein intake level. Sixty-five percent of the world's people have less than we do and are on protein-deficient diets. Chemical fertilizer will account for more, rather than less, of our food in the years ahead.

"What happens to the fertilizer we do put on the land surface? Some reports these days would have you believe that all nitrogen is put on as 'artificial nitrates' and the use of any fertilizer at all is a very reprehensible practice. This overlooks a major factor in our food supply.

"Actually, only about a fourth to a third of our total fertilizer nitrogen applications are in the nitrate form, and in 1968 we used an average of 8.3 pounds of fertilizer nitrogen *in all*

Minimize Sediment Movement into Waters.

- **Minimum tillage of soil.**
- **Keep crop residues on surface.**
- **Use contour cropping and cultivation.**
- **Use sod crops in rotations.**
- **Use sediment trapping structures (terraces, etc.) where needed.**
- **Avoid black fallow and bare land surfaces.**

Table 1. Fertilizer used on wheat for grain, 1969.

	Acres Receiving, % N	P	Rate per A N	P
Minnesota	90	90	32	16
North Dakota	65	72	14	11
Nebraska	48	17	36	15
South Dakota	33	30	23	10

Table 2. Fertilizer used on corn for Grain, 1969.

	Acres Receiving, % N	P	Rate per A. N	P
Iowa	91	88	108	29
Minnesota	90	87	95	26
Nebraska	89	67	143	16
South Dakota	46	42	56	13

forms per harvested crop acre in South Dakota. That's about 3 pounds an acre as an average over all land surface in the state. Geochemists say we receive about 4 pounds of nitrogen an acre annually dissolved in our rainfall — or slightly more than we apply in fertilizer. Complex nitrogen compounds which escape utilization by soil organisms and uptake by plant roots may be converted in the soil to nitrates. Thus, nitrates in soil are derived by natural processes as well as from fertilizers.

Fertilizers Not Sole Cause

"So, let's not deny the presence of nitrogen, which would be untrue. It's there. But don't point to fertilizers as the sole cause. We tend to go to extremes to fix a 'blame-tag' for a certain unwanted condition. We need to look at it from the standpoint of determining a source — often unsuspected — in order to channel our efforts to eliminating or controlling the source rather than just hanging up a blame tag.

"Nitrates are not appreciably adsorbed on soil surfaces, thus they move with soil water. Excessive and sustained *injudicious* use of nitrogen fertilizer can cause build-up of nitrates in ground waters, rivers and likes. One river in Illinois presently has a nitrate nitrogen level of about 18 parts per million. On the other hand, for example, the Wabash river in Indiana is the same as it was 40 years ago in spite of nitrogen fertilizer usage in the basin now nearing 270,000 tons annually. Our own James river at Huron is reported to be one of the lowest in this part of the nation at 0.4 p.p.m. of nitrogen as nitrates, up from 0.15 p.p.m. 14 years ago. I suspect that almost all this increase can be accounted for by livestock feeding operations along the James river and I say that to point out a controllable source rather than to point a finger of blame.

Minimize Nitrate Enrichment of Waters

- **Do not apply nitrogen on frozen soil.**
- **Use split applications on sandy soils.**
- **Stay within recommended rates for optimum yields.**
- **Surface or shallow management of residues.**
- **Incorporate fertilizer when fall applied if surface is smooth.**
- **Avoid monoculture of row crops.**

"Single cropping with row crops offers the greatest opportunity for the formation and movement of nitrates in soils. Scientists have found substantial build-up of nitrates under corn, sorghum, soybeans and sugar beets, but inconsequential amounts under close-grown crops such a grasses and alfalfa. Tables 3, 4, and 5 give some South Dakota information obtained by SDSU Agricultural Experiment Station agronomists in 1969.

High Nitrate Levels

"The inefficient root systems of row crops and extensive cultivation used combine to produce nitrate levels under corn that are 8 to 16 times those of other crops. Some Illinois studies with a nitrogen application rate of 400 pounds an acre followed by two, 2½-inch rains resulted in 1.7% of the applied nitrogen running off. If we make assumptions of similar proportions for South Dakota, our runoff or fertilizer nitrogen might be as much as 1 pound per acre a year on some corn fields. This is inconsequential in comparison to topsoil losses.

"Phosphorus, unlike nitrogen, is extensively adsorbed on soil surfaces and so does not move appreciably within the soil profile with soil water. Phosphorus moves mainly with soil particles. Thus, either wind or water erosion moves phosphorus as fast as, or faster than, the bulk of the soil because erosion is a selective, sorting process always removing smaller, lower specific gravity particles preferentially. Purdue and Georgia University scientists state that eroding soil materials are 2.7 and 3.4 times as rich in nitrogen and phosphorus, respectively, as the soil sources from which they are derived. Some small amounts of phosphorus move in the dissolved phase, but the amounts involved would usually be at least an order of magnitude smaller than the nitrogen in solution.

Turning to the major pollution trouble-maker in South Dakota, Dr. Fine cites a distinction between geologic and accelerated erosion. The South Dakota Badlands represent a classical case of geologic erosion, influenced but little by man's activities. "On the other hand, man's almost frantic efforts to wrest more and ever more from the land through the use of row crops and summer fallow and overgrazing, aided and abetted by almost unlimited

Table 3. Nitrate nitrogen in native grassland soil, Pasture Research Center, 1969.

Depth, ft.	Applied nitrogen fertilizer, Lbs. N/A. 0	60	120	480
	Ave. Nitrate Nitrogen Concentrations, ppm			
0-1	0.7	0.6	0.7	23.9
1-2	0.3	0.4	0.5	11.7
2-3	0.4	0.4	0.4	1.0
3-4	0.5	0.3	0.4	0.5

Table 4. Nitrate nitrogen in alfalfa land, Parker, S. D. 1969.

Depth, ft	Applied nitrogen fertilizer, Lbs. N/A 0	300	600
	Ave. nitrate nitrogen concentrations, ppm		
0-1	3.1	3.4	10.0
1-2	0.9	3.9	16.2
2-3	1.2	1.4	1.3
3-4	0.8	0.9	1.1

Table 5. Nitrate nitrogen in corn land soil, Milbank, S. D., 1969.

Depth, ft	Applied nitrogen fertilizer, lbs. N/A 0	100	1000
	Ave. nitrate nitrogen concentrations, ppm		
0-1	5.5	16.3	80.8
1-2	2.3	7.3	19.8
2-3	3.2	4.2	8.2
3-4	2.3	4.0	3.2

power and machinery, result in water and wind erosion losses that I estimate result in about two times the rate of removal of nitrogen by crops (81 pounds an acre annually vs. 39 pounds).

Tons of Topsoil Lost

Specific information pertaining to soil losses in South Dakota is somewhat limited but research at a farm operated in Lake County by the USDA Agricultural Research Service does give indications (table 6). This Lake County research shows that about 8.5 and 2.7 tons of topsoil per acre per year are lost from fallow and continuous corn, respectively, in 70-foot runoff plots on a 5.6% slope. Much less is lost when any kind of conservation practices at all are used.

Table 6. Soil loss and water runoff, Lake County USDA Agricultural Research Station, 1965-69.

Land use	Culture	Soil loss T/A/yr	Runoff in.
Fallow	Clean tillage	8.6	2.05
Corn	Conventional: plow, disc, harrow	2.72	1.17
Corn	Mulch: surface residue	1.80	1.00
Corn	Till-Plant, up and down slope	1.71	.85
Corn	Till-Plant, on contour	.39	.33

"Watershed and reservoir summary data indicate much greater losses are occurring in the James and Big Sioux watersheds than at the Lake County site," Dr. Fine says. "These losses amount to an average of 1/16 inch (10 tons an acre annually). A loss of 5 tons an acre a year would mean about 81 pounds of nitrogen leaving each acre each year. In other words, there's 81 pounds of nitrogen tossed away to likely become pollution rather than a boost in crop yield."

The SDSU agronomist emphasizes that South Dakotans are lucky because "we are not starting from point zero – application of present knowledge could reduce erosion at least 75%." He adds that his six rules for reducing erosion and the six for reducing chemical fertilizer pollution are not particularly easy to follow. "They are a guide, perhaps a standard, that can be used as a measure by South Dakotans to see just about how far they are prepared to go to help assure their own survival," concludes Dr. Fine. ☐

Remote Sensing of Pollution Sources

Monitoring pollution from aircraft—or spacecraft—in addition to providing a rapid overview of large areas will save costs and time by pinpointing sources where control measures are needed when used in conjunction with ground measurements.

That's the assessment of possibilities for using remote sensing in pollution control by Victor I. Myers, director of South Dakota's Remote Sensing Institute, headquartered on the South Dakota State University campus.

"Although remote detection of pollution is new and much more must be learned about procedures and instrumentation, projections indicate it will be a valuable tool in the effort to improve our environment," Myers added. "The taxpayer concerned by pollution of his drinking water supply and pollution of environment has a rightful concern that detection of pollution should be speedy, of reasonable accuracy, and as economical as possible."

No "Spy In Sky"

Rather than a "spy in the sky," Myers said remote sensing would locate or pinpoint exact sources of pollution so that abatement could be undertaken in particular cases thus avoiding imposition of costly industry- or area-wide control measures regardless of whether or not they are needed.

He said that remote sensing "strategy" should be more than mere monitoring or detection, citing as an example specific placement of livestock enterprises to avoid both air and water pollution. "The specific information provided by remote sensing interpretation for this use would include an area-wide view on small scale photography, topography from photo stereo pairs, drainage patterns, reconnaissance quality of soil types, proximity to other structures and transportation."

Vast areas can be covered in a short time, he explained and pointed out that recently the Institute's aircraft monitored the entire reach of the Missouri River from 20 miles above Pierre to Fort Randall Dam—more than 150 square miles of water in 48 minutes.

Use of Satellites

He described techniques and equipment ranging from anticipated use of earth orbiting satellites (possibly starting in 1972) to thermal infrared sensing that enables an airborne instrument to pick up minor temperature differences on the ground and reproduce them on magnetic tape that can be converted to an image on film resembling conventional photography in certain aspects. Since the first orbiting satellites will have limited resolution capability, their use in pollution surveillance will be limited to gross conditions in lakes, estuaries, and over the oceans.

Remote sensing, Myers continued, holds possibilities in detection and assessment of amount of suspended silt in streams, occurrence and distribution of algae that warn of aging conditions in lakes, and with improvement of techniques possible detection of dilute concentrations of chemicals or dissolved solids.

Thermal Pollution

Thermal pollution is fairly new, resulting when water used for large-volume cooling purposes is returned to a body of water at a higher temperature. This upsets a delicate balance of fish and plant life. It may be industrial or may originate from municipal sewage disposal plants. A similar pollution condition often exists when irrigation water is removed from a stream and drainage water is returned. Spotting the sources of this type of pollution is possible with equipment used in remote sensing, according to Myers.

He stressed the need for accelerated research in applications of remote sensing because of the help it can provide in the "tremendous job of monitoring and surveillance facing us in future detection of pollution problems."☐

A South Dakota State University report:

If wastes are a pollution problem . . .
. . . who's doing what about them?

Trade Trash for Beefsteaks?

How about this for an ultimate in reducing South Dakota pollution:

Trading your household garbage for beefsteak!

Although not as simple as returning empty pop bottles for the cash deposit, the idea is somewhat similar. A lot of wastes, more than likely your household trash included, contain substances capable of becoming a feed when converted by specialized digestive systems of certain animals—in this case ruminants of which beef and dairy cattle and sheep are illustrous examples. It isn't a particularly new idea. Scientists for decades have worked on feeding wastes to animals with varying degrees of success. So don't rush out just yet expecting to turn in the family garbage at the meat counter.

But in the meantime keep your eye on South Dakota State University animal scientists seeking alternate ways to provide feed other than grain for ruminants. If they succeed and at the same time put some converted wastes back into man's food cycle they might have a not-so-incidental spin-off from research which was really designed to promote better utilization of high roughage rations without the usual addition of grain or similar concentrates. A main thrust aims at assuring survival of ruminants in a predicted world where-people, not livestock, will have first claim on harvests of cereal grains.

Using Byproducts

Man's greatest oversight, and perhaps his downfall, someone has said, is that he has failed to fully use waste or byproduct portions of materials that provide him with a high standard of living. Some of our leftover wastes are now becoming difficult to accommodate in our environment; others now catch our attention as raw materials to augment natural resources.

A lot of materials floating down rivers, concentrating in lakes, going up in smoke, stacked in stinking piles, or just lying around in the way contain significant amounts of potential food for man and animal. Much of this is in the form of cellulose, according to Leslie D. Kamstra, Agricultural Experiment Station animal scientist. He explains these potential foods could originate from certain basic compounds that when broken down are chemically identical to energy building blocks (glucose) as those in corn, oats or barley.

Keep Ruminants Runnin'

Only ruminants are able to simplify cellulose into these glucose building blocks and then into volatile fatty acids which possess energy. Non-ruminants — which include humans — can't do this although they convert the starch in grain to glucose. This, adds Dr. Kamstra, is one reason we must "keep the ruminants runnin' " not only for future steaks but for our stakes in the future. Otherwise we might find ourselves over our heads in fibrous wastes of unused cellulose — the most abundant organic compound on earth not directly useable as food by man.

Thus SDSU scientists hope to put the beef cow to work manufacturing steak and other useful products by using unique features of the ruminant's four-chambered digestive system to break down fibrous wastes into grain substitutes. This, to the budding crop of environment watchers, might mean a lot of those pollution eye-sores could be turned into beefsteaks.

Dr. Kamstra, leader of the roughage-utilization-by-ruminants project, suggests the search for suitable roughage sources in South Dakota may have applications to pollution control. "For example, there's a lot of extra sawdust from the lumber industry in western South Dakota which either takes up space or if burned adds another pollutant — smoke," he says.

Sawdust Ration at Newell

"We have beef animals at the Newell experimental substation on pelleted feed which includes sawdust that replaces alfalfa hay in up to 10% of the ration. Later we'll try 50% or more sawdust, even try for an all fibrous ration. We're just starting but preliminary observations indicate no intake problems, the adaptation is good, and we haven't found any serious side effects." Also working on the project are L. B. Embry, A. L. Slyter and J. K. Lewis of the SDSU animal science department. Dr. Slyter, headquartered at Rapid City, supervises the project activities at Newell.

Dr. Kamstra says numerous potential cellulose or fiber sources will be investigated. He points out that usually some form of chemical or physical treatment will be necessary first although it must be fairly easy and economical to be of practical use. As a starter, he suggests these sources: byproducts of the paper industry, waste paper from trash dumps, pulp material byproducts of the fruit and vegetable industry, cereal industry byproducts not used for human foods, byproducts from production of artificial or synthetic meats from plants, textile industry byproducts, recovery of straw and other bedding materials from stockyards or other animal collection points, corn cobs, and the material left after flax straw is processed for use in various manufactured products.

"Sure, we're going to have wastes from the animals — you'd have that regardless of what you feed them," Dr. Kamstra points out. "This byproduct feeding idea at least wouldn't aggravate the animal waste problem."

Dr. Leslie D. Kamstra, professor of animal science at SDSU, holds one of the "cows" in an apparatus which simulates the digestive process in a cow's rumen. Potential new cellulose or fiber sources will be first screened in this apparatus rather than used in live animals. This avoids needless loss of animals if some materials are toxic. These flasks are inoculated with fresh rumen fluid obtained from a live cow's rumen. The apparatus has a capacity of 200 "cows" at the same time.

Potential new materials won't be tried on live animals until after being first screened in a "glass cow" that simulates a live cow's digestive process. This avoids needless loss of animals if some materials are toxic — besides it saves time, effort and money. The laboratory cow is made up of flasks inoculated with fresh rumen fluid and maintained under conditions similar to those in a live cow. The Agricultural Experiment Station has used this screening device for several years on various research projects. The fresh rumen fluid from inside the cow's "stomach" is obtained by reaching through a surgically-installed "door" on the side of a cannulated animal. □

Mary Turner, a technician, measures out a mixture into a "glass cow" used in SDSU digestion experiments with ruminents. Fluids from the rumen of a cow and artificial saliva will be placed next in the test tube to simulate the digestive process of a live animal. Sawdust, wood chips and pelleted ration containing 10% sawdust are in the foreground. Miss Turner, a senior pharmacy major at SDSU, is the daughter of Mr. and Mrs. James Turner of Faulkton.

HOW ARE THEY DOIN'?

After 100 days of feeding the pelleted rations, the "pine sawdust" cattle showed no intake or toxicity problems. Average daily weight gains favored the sawdust fed cattle, and the test-tube "artificial cow" procedure also was in favor of the sawdust rations. Fecal excretion of cellulose increased from 31.4% with the basal ration to 35.3% with 10% sawdust ration. The study used 0%, 5% and 10% sawdust as a replacement for dehydrated alfalfa meal. Basal ration consisted of 50% dehydrated alfalfa meal, 45% ground corn and 5% molasses. Sufficient soybean oil meal was added in place of corn to maintain the sawdust rations at a comparable level of protein (13.1% crude protein) with the basal ration.

SDSU Civil Engineering Department

water resources development

pollution control

Material for this article has been supplied by Dr. James N. Dornbush, professor of civil engineering, and director of the graduate program in Water Resources and Sanitary Engineering; and his co-workers, Dr. John R. Andersen, professor; Dwayne A. Rollag, assistant professor; and Leland L. Harms, instructor, all of the Civil Engineering Department.

There's a lot of engineering involved in water resources development and water pollution control . . .

. . . and there's a lot of water resources development and water pollution control involved in South Dakota State University's Civil Engineering Department with its expanded approach to provide education-research-extension concepts to help meet the needs of South Dakota and the nation.

An outstanding example in education is the rapid development of the graduate program in Water Resources and Sanitary Engineering now in its 5th year. This highly technical and specialized field includes 11 full-time graduate students, with a total of 15 advanced degrees granted during the past 2 years.

An important factor in growth of this program was a 5-year $175,000 training grant from the Federal Water Pollution Control Administration which provided staffing for new course offerings at the graduate level. The recent federal budget included $49,500 for the first year of an additional 5-year training grant of about $242,000 to continue the program through 1975. Grant funds are also available for equipment, supplies, and stipends for graduate students. These additional funds will allow for expansion to include more graduate students in the program.

Sanitary Engineering

Most students in the graduate program in Sanitary Engineering are recent SDSU alumni although graduates of the Universities of Connecticut and Washington have provided a coast-to-coast atmosphere of cooperative learning.

Undergraduate education in the Civil Engineering Department has been strengthened as a result of the sanitary engineering activities and has included research projects for these students. Six undergraduates have participated in the National Science Foundation sponsored program over the past several years. Benefits to these students included the opportunity for individual advanced study, along with financial support.

The quality of achievement of one of these undergraduate research participants was formally recognized when he tied for first place in SDSU's undergraduate research contest with an investigation of organic contamination of ground water. In addition, he received honorable mention in the Schulz-Werth undergraduate research competition.

Geared to South Dakota

The Civil Engineering department's research program, associated with the graduate program in Water Resources and Sanitary Engineering, is geared to solving problems in South Dakota. A typical example is an investigation on the Big Sioux river below Sioux Falls, an excellent example of cooperation between SDSU, industry, municipal, state and federal agencies to help solve water pollution problems.

Sioux Falls, a major metropolitan center of the state on the Big Sioux river, has excellent wastewater treatment facilities. However, the river sometimes has a minimum flow of less than the wastewater discharges. The Big Sioux studies are concerned with the future uses of the river including recreation, irrigation and public water supplies. Along with these factors, the influence of the potential development of reservoirs on the river to provide flood control as proposed by the Corps of Engineers is being evaluated. One primary objective is to determine wastewater treatment requirements to enable the city to plan for the future.

The Big Sioux project was also aimed at predicting the impact of the water quality standards that have been established by the South Dakota Committee on Water Pollution for all streams in the state as a result of the Water Quality Act of 1965. These standards establish for all rivers, streams and lakes in South Dakota the required water quality for beneficial uses including domestic water supply, fish and wildlife, irrigation, recreation, livestock watering, and industrial uses. The Standards also set forth the uses to which streams with little or no flow can be subjected.

Financial support of the project has been supplied by SDSU Engineering Experiment Station, the East Dakota Conservancy Sub-district, the City of Sioux Falls and John Morrell & Co., with a federal matching grant from the U. S. Department of Interior through the South Dakota Water Resources Institute which is headquartered on the SDSU campus.

Industrial Development

Future industrial development of the state is being taken into consideration by the research program in Sanitary Engineering. For example, research on anaerobic lagooning of meat processing wastes has produced significant results. This economical method of treating the high-strength wastes from the meat processing industry is particularly adaptable to South Dakota conditions. Following the design and evaluation of the initial installation in this area at Luverne, Minn., small meat packing plants have been quick to adopt this method of solving their wastewater treatment problems. Systems in operation employing this economical method are at Huron, S. D., Cherokee, Ia., and Worthington, Minn.

Additional studies "zeroing in" on the growing animal waste disposal problems of the livestock industry are continuing. Earlier studies investigating lagooning of water-carried livestock wastes have been extended to evaluate the pollution problems associated with feedlot runoff. The results of these studies are also expected to have considerable bearing on pollution control requirements of the livestock feeding industry necessary to comply with the water quality standards for South Dakota rivers, streams and lakes.

Surface waters such as lakes and streams are not the only concern. Ground water is also under study. The importance of ground water to South Dakota is readily apparent when it is noted that of the state's total of 250 municipal water systems, 225 derive their entire supply from wells. Also sub-surface formations are a primary source of irrigation water. The extent to which pollution of this valuable water resource is occurring is therefore a matter of vital concern. In cooperation with the City of Brookings, research efforts have been directed toward learning more about these effects. These studies have shown that refuse disposal by burial can substantially alter the ground water quality. To date, changes in the ground water quality have not occurred to the extent that users of the water would be adversely affected. However, this research has demonstrated that indiscriminate burial of refuse could ruin some excellent ground water sources.

How About Lagoons?

Wastewater stabilization ponds or lagoons may also represent a hazard to ground water if proper precautions are not taken in their construction. These man-made ponds in many cases receive the raw sewage from communities. If the ponds leak excessively, large amounts of sewage could enter the ground water and contaminate it. Graduate students in sanitary engineering have been researching methods of economically sealing these lagoons to prevent ground water contamination. Another concept under investigation considers engineering the seepage potential to provide high quality lagoon effluent.

A plan for ground water management for the Big Sioux River is presently under study by one of the graduate students. The plan envisions a series of small overflow dams with control gates suitably located and capable of raising the water level in the channel by several feet. The expected result would be water storage in the channel but more important, also in the adjacent aquifers where it would not be subject to evaporation losses and could be developed for irrigation.

"It's a far-out plan," according to Jerry Siegel, recent graduate of the program and presently Planning Engineer for the East Dakota Conservancy Sub-District in Brookings, "but the topography of the Big Sioux Basin may just make it feasible."

Other projects now under preliminary investigation by graduate students may also prove highly beneficial to South Dakota. One such preliminary study is to evaluate the benefit of combining lime sludge from water softening plants with sludge from the sewage treatment plants for final disposal. If this combination proves as beneficial as preliminary results indicate, communities such as Sioux Falls, Huron, Vermillion, Aberdeen, Rapid City and Brookings with both water softening and conventional sewage treatment may reap the benefits.

Engineering Extension

Extension activities in the sanitary engineering field have provided benefits to South Dakota for years. The Waterworks and Sewage Works Operator's Short Courses held annually on the SDSU campus have grown in attendance to over 100 persons. This association of operators and SDSU staff members has proved valuable in meeting South Dakota problems in sanitary engineering plus helping to develop educational, research and extension activities to meet the challenging problems of this state.

"We haven't even scratched the surface in making contributions to South Dakota," says Dr. James N. Dornbush of the Civil Engineering Department in talking of the potential of sanitary engineering education at SDSU. "This state is plagued with brackish ground water supplies used for domestic purposes. Iron and hardness concentrations are among the highest in the United States. We would certainly like to come up with something to economically cope with these problems. The problem of pollution of our lakes and streams is a long way from solved. Doctorate education and research will certainly help. Our communities also need more assistance to help them train the operators who are responsible for their water and wastewater facilities. We are making progress but there is so much to be done."

Dr. Dornbush and his colleagues point out that although the program is officially less than 5 years old and its graduates are just getting started professionally, there is little doubt that among them will be found many of the leaders who will guide our state and nation in the technological battle against water pollution and the full development of our waer resources.□

A South Dakota State University report:

If organic wastes are a pollution problem . . .
. . . who's doing what about them?

Billions of Pollution "Trackers"

The countless billions of bacteria associated with organic materials in our streams, lakes and other waters are being used as "tracers" by South Dakota State University scientists to help determine when, where and how much pollution originates from human and animal wastes.

SDSU Bacteriologist Paul R. Middaugh says: "We could use radioactive materials too, but why do that when we have a free supply of 'built-in' bacterical material that help provide us with telltale evidence of whether or not pollution is a problem, where the pollutant comes from, and comparatively how much is present.

Additionally, the research is providing new insights on disease-producing bacteria, of which bacteriologists are finding ". . . more than a little in our environment and in increasing amounts."

Dr. Middaugh, who's as enthusiastic about training young bacteriologists in the classroom as he is in Agricultural Experiment Station research, says that "what we don't find" sometimes provides clues that scientists in other fields may explore. For instance, if a water sample doesn't show dangerous amounts of bacteria associated with wastes but does contain considerable nitrogen or phosphorus then it might come under the work of a soils specialist, an engineer or other specialists.

Pollution Detective Work

Several years of bacteriological pollution-detective work has established that certain bacteria are associated with human wastes, others with wastes from certain kinds of animals (ruminants or non-ruminants, for example), while still other bacteria are associated with both. They are so tiny you can't see them with the naked eye. The indicators are fecal coliform bacteria (which appear as rods under the microscope), fecal streptococci (which appears as a chain of dots microscopically), and disease-causing bacteria currently being studied including *Salmonella* and its near relative *Arizona,* and *Escherichia coli*—the "enteropathogenic *E. coli*" associated with serious intestinal infections of infants.

By identifying these bacteria, a pollution source may be found to be a livestock feedlot—or, as Dr. Middaugh likes to point out, evidence may be found to show that the feedlot is *NOT* the source. Actually, as is the case in so much research, the bacteriologists are looking at things more from a sanitation standpoint and in doing so they are coming up with findings that fit into the fight against pollution.

Seek Pathogenic Bacteria

The bacteriologists have been looking for pathogenic bacteria—the ones that cause diseases in man and animal. One of the strains being found more frequently, for example, is *Salmonella,* some types of which in man cause diarrhea, often severe and disabling, and weight loss in farm animals. The main problem, up to now at least, has been the difficulty in finding or identifying these strains out of the millions of other bacteria in a water sample.

This is the point where the bacteriologists have been developing the "tracer" techniques. Instead of looking for only the hard-to-find disease-causing bacteria, the investigators now first look for the "indicators" of organic wastes which, mainly because of large numbers, are more easily spotted in a given water sample. When these indicators show presence of organic wastes, a closer look is made for disease-type bacteria.

Another step—and there are encouraging results here—is to improve the speed, sensitivity and accuracy of isolation methods for the various fecal coliform bacteria and fecal streptococci in farm runoff and of streams. As Dr. Middaugh explains, "We're looking for a way in which a technician can rapidly get a 'yes' or 'no' answer as to presence of the bacteria for each of dozens of water samples that would be tested." The technique would be simple enough so that a minimum of specific training is necessary for the technician. A "yes" answer, indicating organic wastes are present, would mean further tests to show comparative ratios or numbers of bacteria types to help locate organic waste sources and if they are of human (usually municipal) or animal origin.

New Detection Methods

Improved methods for isolation of the organism *Streptococcus bovis* have been developed at SDSU which permit routine enumeration of this fecal bacterium from waters of the Big Sioux River. A rapid new method to detect

Ralph Pierce, SDSU graduate research assistant, can pick up just one salmonellae cell in an ounce of river water.

S. *bovis* was developed in 1969 by a graduate student, Lawrence Koupal of Wagner, S. D.

S. *bovis* is one of the bacteria which breaks down basic nutrients in the unique 4-compartment digestive process of ruminants. It has been found in feces of ruminants (cattle, sheep, goats) but not in other animals (non-ruminants such as swine, horses, poultry) or man. Thus it can serve as an indicator of presence of feces from ruminants in water or on land. J. E. Tiede, a graduate student of Mitchell, S. D., now with the Green Giant Co., Belvidere, Ill., applied one of the new methods to isolate and characterize 302 representative fecal streptococci from three typical water sources—the James River, a dairy lagoon, and a municipal waste discharge. The types of waste could be distinguished by their characteristic flora of fecal streptococci, especially from the dairy lagoon which contained 3% S. *bovis*. Typical *Streptococcus faecalis* and its related species accounted for over 90% of the isolates.

Relative die-off, or survival, rates of the fecal organisms in water may provide additional ways of using them as pollution tracers or as indicators as to how long the water may be dangerous. Graduate student Joe W. Zerfas of Sioux Falls in 1969 found that S. *bovis* can survive in river water for several days and S. *faecalis* for 6 weeks.

Disease-Causing Bacteria

The increasing presence of *Salmonella* disease-causing bacteria (which originate only from human and animal wastes) in regional rivers may turn out to be a matter of growing concern from the health standpoint, according to Dr. Middaugh. All of the first 12 isolates in a sampling from the Big Sioux River turned out to be *Salmonella typhimurium*, known to be one of the most infectious strains for man and for farm animals.

Something of a breakthrough has been accomplished by Dr. Middaugh and one of his graduate research assistants, Ralph Pierce of Horton, Kansas. They have used the membrane filter technique combined with specific fluorescent dye from antibodies to detect salmonellae cells in very low numbers in small samples of river water. "Pierce has been able to pick up just one salmonellae cell in a sample of only about 1 ounce of water," the Agricultural Experiment Station bacteriologist says. "Bacteriologically, this is comparable with being able to find a needle in a great big haystack."

Dr. Paul R. Middaugh, SDSU bacteriologist, teaches and does research concerning bacterial tracers in organic wastes. He maintains that public support of "action agencies" will help greatly in the pollution battle. He says "we know enough to get started —let's get going."

Joseph L. Gadberry, an instructor in the SDSU bacteriology department, is looking for evidence of *Salmonella* directly out of feedlot animals. He is working to improve methods in which selective antibiotics serve to provide a rapid "yes" or "no" answer. More than 1,200 distinct serotypes of *Salmonella* are known although less than 60 account for about 97% of those isolated from illnesses. According to Dr. Middaugh it is evident that many strains infect both farm animals and man. He says nearly half of the feedlots in an investigation by USDA in Florida were positive for *Salmonella*. He speaks of the vicious circle for continuance and spread of *Salmonella* as illustrated in poultry. It has been shown, he explains, that meat scraps for protein supplement in poultry rations if improperly rendered (not steamed and heated) are a potential source of *Salmonella*. The *Salmonella*-containing supplements are fed to chickens which become infested with the bacteria, then pass them on to other chicken hosts. Thus the life cycle of the dangerous bacteria continues unbroken. "We don't know if the same thing may apply to some high protein supplements in livestock rations," he adds. The animal Disease Research and Diagnostic Laboratory on the SDSU campus receives 10 samples from 10 rendering plants in the state every 3 months for surveillance for evidence of *Salmonella*.

More Knowledge Needed

More needs to be learned about the environmental effects of these bacteria and how they act as possible debilitating infections of animals. The SDSU bacteriology lab and the state health laboratory are the only ones in South Dakota and among only a few in the United States doing research on these methods of rapid, sure and simple methods of using bacteria as pollution tracers.

"Our work in bacteriology," Dr. Middaugh points out, "is usually in conjunction with other agencies or scientific fields. We attempt to develop methods to monitor water supplies and if we can pinpoint pollution sources we do so. We don't go in and do the nuts-and-bolts control work, that is where the engineers and others come in to devise and design systems or methods to prevent or control pollution.

"That's one reason I consider the training of bacteriologists so important. We've got to have these trained people for a variety of jobs—many jobs possibly as yet undreamed of—dealing with sanitation and contributing what they can to a compatible environment. Much of this will be done through state health agencies which must be permitted to do the intended job through sufficient staffing and support."□

A South Dakota State University report:

Insecticide residues in South Dakota . . .
. . . who's doing what about them?

Residues: A Warning Sign

If we smugly sit around pointing out that South Dakota pollution by agricultural chemicals of waters, land and wildlife is not high in comparison to many problem areas (which is true), we are sadly missing a critical warning.

Because, says a South Dakota State University biochemist, the mere fact that these pollutant residues are present at all means that control or preventative measures should be taken without delay.

"What are the solutions, what can we do?" you ask.

"Whatever we do isn't going to be easy or cheap," answers Yvonne A. Greichus, assistant professor in the SDSU Agricultural Experiment Station biochemistry department. "But first, we'd better be doing what we can and know how to do now, and in the meantime hope there are sufficient facilities, personnel and funds—and time!—to enable us to scientifically go into the unexplored areas of our environment and come up with more knowledge."

Then Dr. Greichus begins to pose questions of her own: "What have you done about planting trees and grass around ponds, lakes and rivers to decrease soil runoff? What would you do—what would be your reaction—if some authority came along and told you as an individual or as one of a group that you *had* to plant the trees and grass, that you *had* to use only a certain chemical in a certain way in treating that weed-infested lawn? On a downtown street, if you asked the first 10 persons you saw, how many of the 10 could name even three of the long-residue insecticides?"

This article is partially based on a paper, "Importance of Agricultural Biocides in Water Pollution" given by Yvonne A. Greichus, biochemist, at an Agriculture and Water Quality Symposium at South Dakota State University, March 17, 1970.

Most Are Efficient

For the most part the insecticides, herbicides, fungicides, rodenticides and fumigants have been very efficient in destroying animal or plant pests. Only a few of the many hundreds of types of these chemicals have been suspected or shown to contribute to pollution. The major characteristic of agricultural chemicals that cause pollution is that once applied they are not easily removed from the environment—their residues are long-lived, not easily broken down into less-harmful substances. In one Federal study, DDT residues were still being found on land where the insecticide was applied 17 years before. Because of their residual properties they are easily transported by wind, water and soil movement to places where their effects were not intended.

An organochlorine insecticide by itself as a chemical compound is not a pollutant, Dr. Greichus points out. But when it is moved into an unwanted place—for instance, into a lake, or into a bird, or into a human—it is definitely a pollutant liable to be dangerous. Just how dangerous we do not know in too many cases, she says. We're playing a sort of environmental Russian roulette.

Organochlorine insecticides are the ones spotlighted for most criticism. Some of those used in South Dakota include DDT, dieldrin, aldrin, lindane, heptachlor and toxaphene. Dr. Greichus points to evidence that indicates insecticides are spread over the earth by wind and water much the same as radioactive fallout so it doesn't necessarily mean they must be used extensively in any one area to become a pollutant in another. Studies elsewhere have shown every major U. S. river system has insecticide residues. Samples of water collected from the Antartic by Dr. Raymond Dillon of the University of South Dakota and analyzed in the SDSU laboratories were found to contain residues of DDT.

Dr. Yvonne A. Greichus, assistant professor, Agricultural Experiment Station biochemistry department.

Another Villain?

And before you blast agriculture too roundly as a source of chemicals in the environment, take a look at a non-insecticide compound you probably use every day that may turn out to be a bigger villain than DDT and some of the others. Dr. Greichus says residues from a group of compounds known as polychlorinated biphenyls (PCB) are showing up in wild cormorants and pelicans analyzed in SDSU laboratories and ranged up to four times higher than insecticide residues.

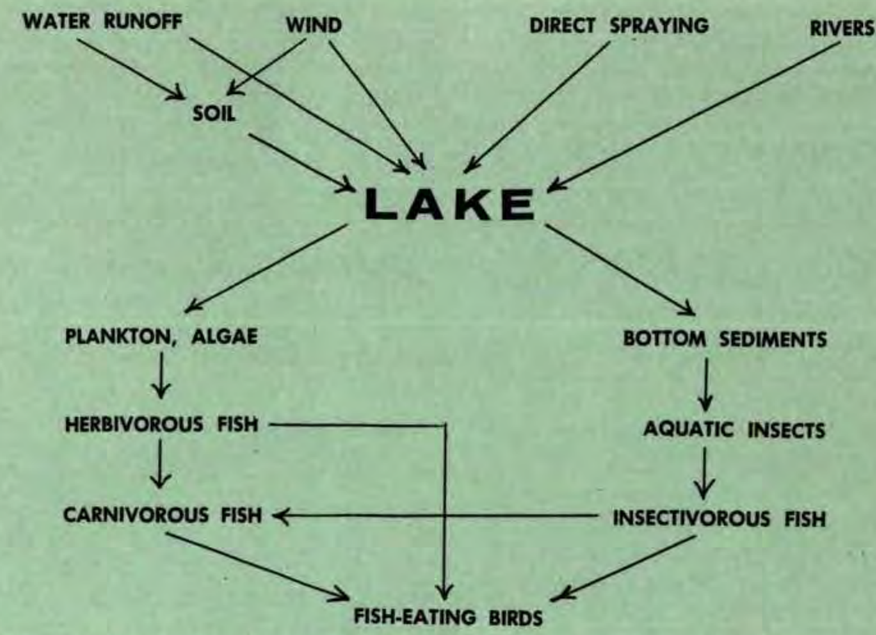


Figure 1. Pathways of insecticide residues in an aquatic environment.

These PCB compounds have similar properties to insecticides in that they are very residual, nonvolatile, non-water soluble and widely distributed in the environment. They are used commercially as plasticizers, protective coatings, extenders and sealers and in products such as inks, lubricants, asphalt, waxes and adhesives. Although little is known about their biological effects, they interfere with the enzymatic systems of animals. Because of similarities it is difficult to separate them from insecticides when making residue analyses. The Agricultural Experiment Station Biochemistry laboratory at SDSU and two others in the United States are currently cooperating in an effort to standardize procedures of analysis.

Dr. Greichus for the past 4 years has been detecting insecticide residues in South Dakota big game animals, wild birds and fish. Table 1 shows these average residue levels.

Note that all types of animals except fish and fish-eating birds averaged less than 1 p.p.m. (parts per million) of all organochlorine insecticides. Average levels in big game animals and Lake Poinsett fish are well below Food and Drug Administration tolerance limits. Poultry has no set tolerance limits.

Wildlife Studies

Dr. Raymond L. Linder of the South Dakota Cooperative Wildlife Research Unit, has studied effects of insecticides on pheasants for several years. Some of the findings include: Pheasant hens receiving 6 milligrams (less than 0.2 of an ounce) of dieldrin per week lost body weight and laid fewer eggs than hens receiving no dieldrin. Birds hatched from eggs of hens receiving the 6 mg. dieldrin had lower food consumption and lower production, fertility and hatchability of eggs. Indications were that dieldrin passed via the eggs laid by hens receiving 8 mg. per week affected the behavior of their offspring. Insecticide levels in brains of wild pheasants did not differ greatly from experimental pheasants which received dieldrin via the eggs. No effects were found on shell thickness of eggs laid by hens receiving up to 10 mg. of dieldrin a week.

Analyses completed in 1965 showed that concentrations of insecticide residues in 27 South Dakota lakes were similar to those found in many other U. S. lakes. The South Dakota average was 0.2 p.p.b. (parts per *billion*) with North Lake Andes being highest with 0.9 p.p.b. Lake Poinsett averaged 0.2 p.p.b. in both 1965 and 1968. (The average level of 0.2 p.p.b. expressed another way would be the equivalent of 1 teaspoonful in 14,000,000 gallons of water).

Pesticides dissolved in water or adhering to soil particles move into lakes during runoff from surrounding land. Many pesticides vaporize and are carried into water by wind. Once in the lake, insecticides may be absorbed by plankton or algae or may settle to the bottom along with soil particles. Aquatic insects, herbivorous and bottom-dwelling fish accumulate insecticide from the bottom sediments and from the plant life. Carnivorous fish eat other fish and finally the fish-eating birds eat all types of fish. Figure 1 illustrates how pesticides enter lakes and are finally concentrated in bodies of fish-eating birds.

Grass, Trees Help

The SDSU biochemist suggests that land use practices such as planting trees and grass around all lakes and rivers to decrease soil runoff would help prevent most of the water contamination by insecticides besides decreasing siltation and organic enrichment of the lakes.

The Lake Poinsett ecosystem has been studied with funds from the Water Resources Institute and the State of South Dakota. This locale was selected because it is typical of lakes in the Great Plains which are warm-water, shallow, alkaline lakes with adjoining crop lands and because of its importance as a recreational area and its commercial fishery. Water, bottom sediments, algae, plankton, aquatic insects and 14 species of fish were analyzed for residue levels of 10 insecticides. The results are summarized in Table 2.

It was found that age and fatness affected concentration of insecticides with older, fatter fish accumulating the highest residues. Even the concentration factor of insecticides in fish compared to water, which was 790 times

(Continued, next page)

Table 1. Chlorinated insecticides in fat of wild animals of South Dakota.

Animal	Number analyzed	Parts per million	% Total DDT + metabolites
Elk	2	.05	100
Antelope	54	.09	62
Deer	36	.19	92
Mountain goat	13	.59	73
Grouse	46	.48	58
Pheasant	48	.51	72
Lake Poinsett fish	100	3.60	79
Pelicans and cormorants	8	150.0	88
Polychlorinated biphenyls		Range 2-260 Average 87	

greater and is considerable, these fish have not accumulated insecticide levels as great as fish in many other parts of the United States.

Fish-Eating Birds

For several years, pelicans and cormorants nesting on Lake Poinsett have been monitored for organochlorine insecticide residues. It should be pointed out, Dr. Greichus notes, that residue levels in the birds have resulted not only from eating fish in Lake Poinsett but also from fish eaten at the bird's wintering grounds in the southern part of the United States. DDE, a metabolite of DDT, has been concentrated to a greater extent than any other residue. DDT, the parent compound, is converted to DDE by enzyme systems, and as it passes along the food chain more and more DDE is formed.

These studies have shown that fish-eating birds, which constitute the highest level of the food chain in the lake, have the highest insecticide residues of any type of animal examined in South Dakota. A new investigation was started last year to determine the

Table 2. Average concentration of insecticides in the Lake Poinsett ecosystem.

Sample	Parts per million (p.p.m.) wet weight	Concentration factor over water
Water	.0002	
Bottom sediment	.0034	18X
Crayfish	.0034	18X
Plankton, algae	.007	37X
Fish	.150	790X
Aquatic insects	1.395	7,300X

effects of DDT and its metabolites on the physiology and behavior of penned cormorants. This study is cooperative, involving veterinary science, psychology, entomology-zoology, and station biochemistry departments.

The new study will attempt to correlate insecticide levels with tissue damage, changes in blood chemistries and abnormal behavior. An examination of effects of insecticides on external and internal parasites is included in the study.

Effects on Birds

For many years it has been suspected that the decrease in many species of birds such as the bald and golden eagle, brown pelican, peregrine falcon, osprey and others was related to the accumulation of insecticides in their tissues and eggs. Analysis of eight wild cormorant eggs revealed average levels of 34.2 p.p.m. of organochlorine insecticide residues and all eggs had embryos. Average levels in nine white pelican eggs were 24.5 p.p.m. and the eggs had no discernable embryos. This leads some investigators to believe that the white pelican will soon become an endangered species along with the brown pelican.

But why go to all this trouble for the pelicans and cormorants?

The answer is that it is more than "just for the birds."

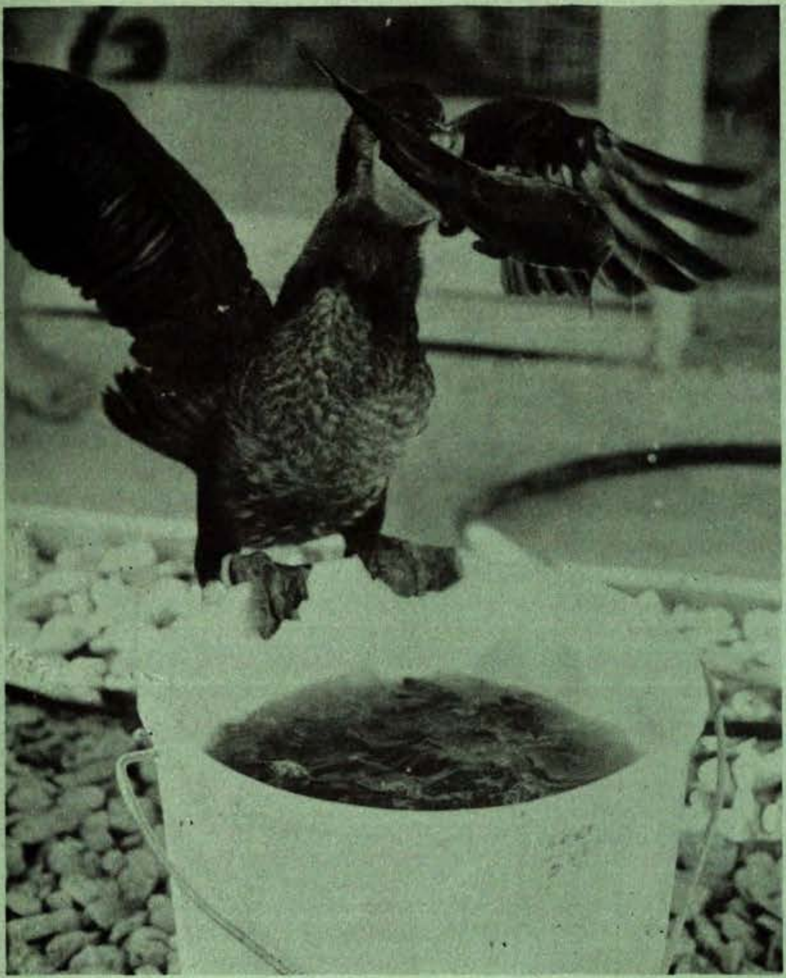
"Even if the thousands of naturalists and wildlife fanciers were not to be considered—and they have a voice just as anyone else—we need to learn more about these organochlorines," replies Dr. Greichus. "If these birds, as part of our environment, are actual or only illustrative 'indicators' of what man may be facing, we need all the clues available to arrive at the place where we can describe specific solutions—perhaps even antidotes."

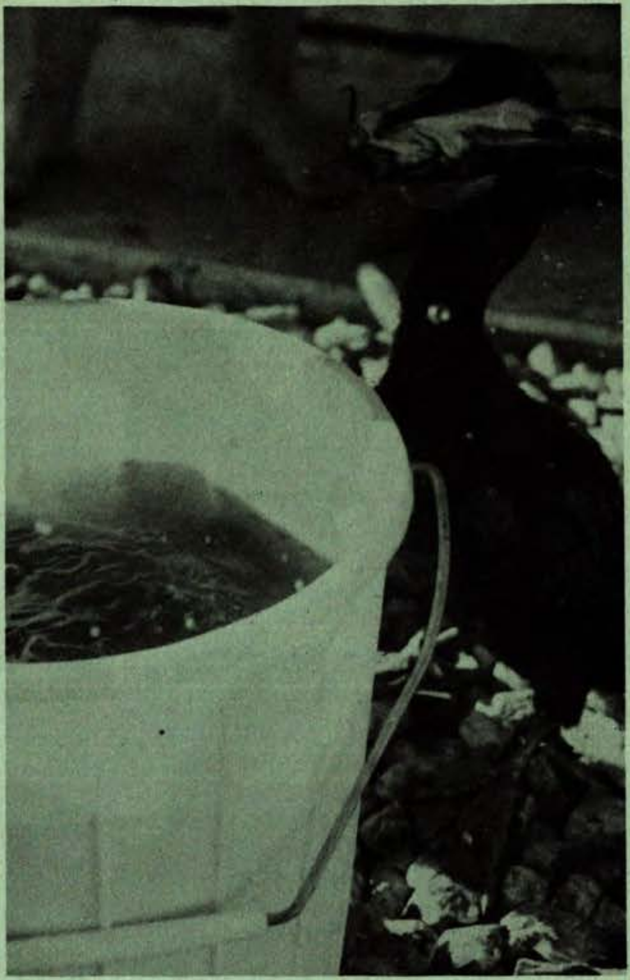
The biochemist said that in another phase of the experiment video-tape recorders will be used to view the behavior of birds, allowing psychologists to possibly relate any abnormalities to insecticide intake. Some of the birds will be trained to perform certain functions relating to learning ability.

This investigation will be somewhat different from many others in that it will be seeking the *chronic* not the toxic level effect of insecticides. "We're not attempting to see how much of an insecticide it takes to kill a bird, we're more interested in just how small an amount it will take to begin to show in the health, activities and reproduction of these birds," she added.

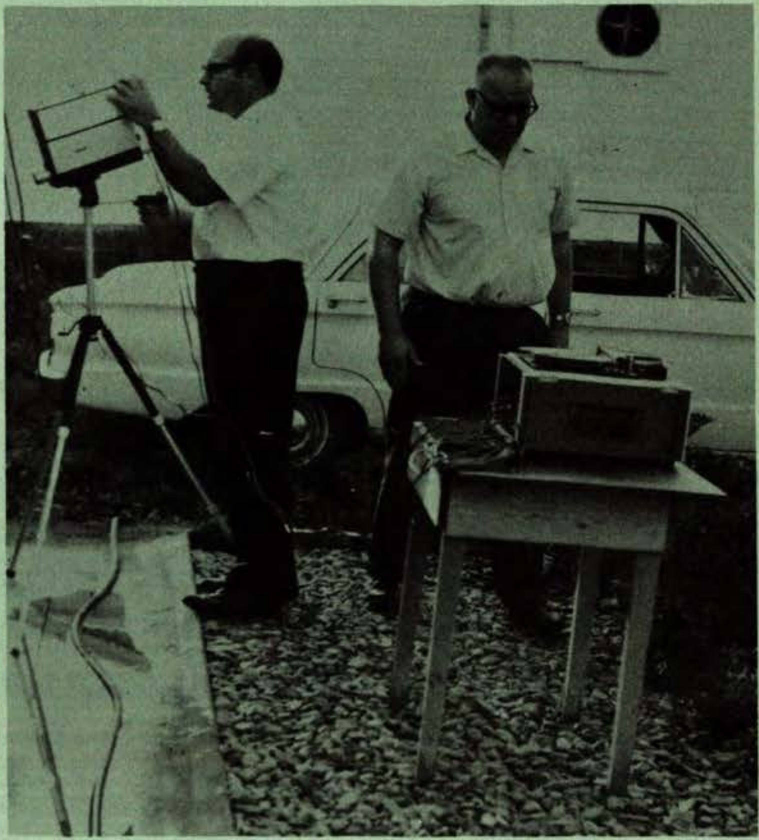
Why use cormorants in the study?

"We could use pelicans which are much admired, they are big, and they fly majestically," answer Dr. Greichus. "But the pelicans eat so much that the smaller, more available cormorants are a better lab bird. By using pelicans we'd have to set up some sort of logistical system to provide for about 5,000 pounds of fish a week to feed them. That's a lot of fish. Cormorants will eat about a fifth of that."☐





(Above). Providing fish for the cormorants is a hefty logistical problem, but not as much as if pelicans were being used. Bullheads are the main item on the menu.



(Right). Psychologists video-tape activities of cormorants to observe any specific behavioral differences between treated and control birds. This shows preliminary work in setting up experimental procedures.

(Facing page). In preliminary studies these cormorants were taken as wild nestlings from a rookery on Lake Poinsett. After a time to adjust to captivity they were divided into experimental groups in cages such as these.

Photos pages 20 and 21 taken by Gordon De La Ronde.

A South Dakota State University report:

If feedlot runoff is a potential pollutant . . .
. . . who's doing what about it?

Seek Data in Feedlot Research

Agriculture and engineering at South Dakota State University are cooperating in feedlot pollution control research aimed at coming up with information that can be used by livestock producers, governmental agencies, and persons concerned with commercial feedlot design and construction.

Although the research has only been underway for slightly over a year, considerable preliminary knowledge has been obtained. Added to this is information gained from research and experience elsewhere which those in charge of the project believe has an application to South Dakota.

Dr. James N. Dornbush, professor of civil engineering, and John Madden, of the Water Resources Institute, who have been conducting this phase of the research, have briefed some of their findings and preliminary conclusions in the accompanying material.

Aerial views of two of the feedlots included in the study, taken in early March 1969. At left a 40-acre commercial feedlot, at right the SDSU livestock nutrition unit.

GENERAL BACKGROUND

One of the biggest problems in livestock production has been actual layout of the feedlot and the feed handling system. Most convenient operation is with maximum animal concentration and minimum feed handling. Such a system also requires that the feedlot be well drained to keep animals clean and out of the mud. Drainage is a prime criterion for any feedlot layout.

Objectives of this research project, sponsored by the Water Resources Institute, are: determine quantity and quality of runoff; determine influence of spring runoff in South Dakota; determine pollutional characteristics of suspended matter in the runoff.

This project is somewhat unique in that studies are being made of actual commercial feedlots. Most previous work has been on small lots under controlled conditions. Currently runoff from seven feedlots is being measured, including a 70-acre lot with facilities for feeding in excess of 20,000 sheep and a 3,000-head commercial cattle feeding operation. The project started in February 1969, soon enough to include measurements of runoff from the record 1968-69 winter snowmelt. Availability of commercial feedlots for this study was possible through cooperative efforts of the South Dakota Livestock Feeders Association and the Cooperative Extension Service.

Of the pollution problems associated with feedlots, the major ones result when heavy rainfall reaches the lot. The resulting water-solids mixture that is transported with uncontrolled runoff has the potential of creating serious water pollution problems.

A major conclusion is: **The South Dakota livestock feeding industry can expand rapidly and still avoid the pollution problems that have occurred in other areas.**

Number of Cattle in South Dakota and National Rank (Jan. 1, 1969)

Type	1,000 head	Rank
All cattle and calves	4,366	8
Calf crop	1,770	8
Beef cows	1,686	6
Cattle on feed	406	11

SOUTH DAKOTA'S ADVANTAGES

South Dakota offers several advantages which should be considered by potential feedlot developers and which we should exploit or "cash in" on in prevention and control of pollution from agricultural sources. Some of them:

Number of Feedlots. South Dakota's

large number of small feedlots offers dispersion of the industry which has probably—up to now, at least—prevented the concentration of water pollutants to the extent that major fish kills have occurred. This also could be a disadvantage if all-inclusive, impractical regulations would be adopted which would result in a monumental administrative problem to investigate and evaluate the potential pollution problems of individual lots in order to issue and update the required permits. In South Dakota the pollution control efforts need to be directed to the largest feedlots, perhaps the upper 2% with over 500 head in the lot, as well as to those feedlots adversely situated adjacent to lakes and streams where the pollution hazard is the greatest.

Estimated number of cattle feedlots in South Dakota, 1967.

Animals per lot	Number of lots
Less than 100	12,100
100-300	2,600
300-500	600
500-1,000	200
More than 1,000	100
TOTAL	15,300

Precipitation. Although considered adverse for some agricultural practices, precipitation patterns appear to be a clear-cut advantage to the South Dakota livestock feeder from a pollution control standpoint. Most of South Dakota has less than 20 inches of precipitation annually compared with 24 inches for part of Kansas and over 40 inches in the eastern part of Kansas. Iowa, the leading cattle feeding state, averages over 30 inches of precipitation annually.

Runoff. Runoff in South Dakota averages less than the equivalent of 1 inch of rainfall per year. By contrast, annual runoff for eastern Kansas, much of Iowa and Missouri averages more than 5 inches and in some areas over 10 inches.

General. Other climatic factors could also be expected to have bearing on the relative pollution potential of livestock operations in South Dakota. The nature of the precipitation, snow or rain, rainfall intensity, the relative temperature, and evaporation could all affect the runoff, as well as the natural stabilization of the wastes that takes place on the lot. Soil conditions would also be important. Fortunately, the available knowledge indicates that most of these factors are favorable to reducing the feedlot pollution potential in South Dakota.

POLLUTION CONSTITUENTS IN ANIMAL WASTES

- Oxygen-demanding materials that consume oxygen needed by aquatic life in lakes and streams, unbalance the ecosystem. This is considered of major importance. In Kansas, where water pollution from feedlots is a major problem, an estimated 80% of fish killed from 1964 to 1967 resulted from manure, silo and feedlot drainage. Undiluted feedlot runoff is a high strength waste. "BOD" (biochemical oxygen demand) which is a measure of organic load is often used as an indicator of the strength of the wastes. A medium strength domestic sewage would have a BOD of about 200 parts per million. Dilution of the organic load (such as during heavy rains or floods) in the feedlot runoff will generally reduce oxygen demand characteristics (BOD) in the receiving stream to tolerable concentrations—but this should not be construed as a control measure.

- Fertilizing nutrients including nitrogen and phosphorus, which on land serve to stimulate plant growth, are equally effective in the water. Growths of algae—the small plants that turn our lakes green in summer—can be stimulated to nuisance proportions, fouling rocks and ramps, causing odors, and generally limiting the recreational potential of the lakes.

- Other solids transported with runoff water, such as sediment, tend to fill lakes hastening the evolution from lake to marsh. Bacteria may also be included in this group of "other solids" often resulting in high coliform counts occurring with feedlot drainage which may unnecessarily limit recreational development of receiving waters. (See article elsewhere in this issue about "tracer" bacteria).

PRELIMINARY FINDINGS

Results from two feedlots used in the experiments show that less than 5% of the oxygen-demanding materials produced in the feedlot from January 1 through June 30, 1969 were removed by runoff.

ACTION CALLED FOR—NOW

This is the way the two researchers working on this livestock feedlot runoff project summarize the first year of their work:

"Although research can be expected to provide greater related knowledge and must be continued, there appears to be great advantage in getting started on a positive program of active feedlot pollution control particularly with all planned new construction for expansion of the feeding industry."

Amount of waste removed by runoff will depend greatly on the slope of the feedlots and drainage ditches. This is also true of soil erosion. In other words, the greater the velocity of the runoff, the greater the carrying capacity of the runoff water.

Generally, these preliminary results indicate that the amount of waste removed by runoff is less than most people had anticipated. Present methods of diverting excess runoff and detention of feedlot runoff will greatly minimize the pollution potential.

Although results tend to indicate less of a problem than anticipated, they emphasize the need for practical planning and operation to prevent pollution potential from erupting into a major problem. One of the key ideas is *PREVENTION.*

RUNOFF QUANTITIES

The 1969 runoff season provided information that can be used to make estimates of annual losses carried with feedlot runoff for an acre of feedlot. For an average acre of feedlot this amounted, annually, to an estimated runoff which included 1,500 pounds of BOD, 11,000 pounds of solids, 700 pounds of nitrogen, and 450 pounds of phosphorus. This illustrates that total losses from large lots are substantial and could be very damaging if discharged into lakes.

However, to maintain a proper perspective, it should be recognized that an acre of feedlot had an annual loss in BOD at the measurement point (which would be the pollution potential) about equivalent to the annual contribution of 25 persons to a city sewer system. Considering that

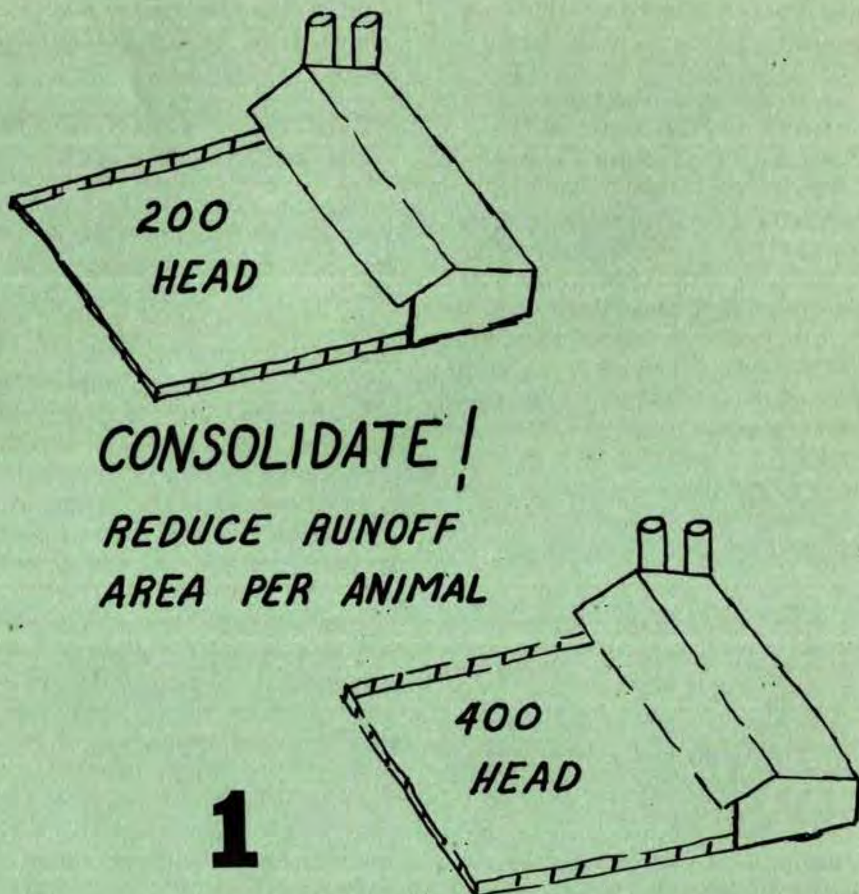
1 acre of lot is sufficient area for feeding about 250 head of cattle, it then appears, on an annual basis, that for South Dakota 10 head of cattle on feed is equivalent to about 1 person rather than the opposite, 10 persons for 1 head of cattle, which is frequently reported when discussing population equivalents.

The basic difference in making such comparisons results when the fate of BOD in the animal wastes is considered. Much organic matter is stabilized in the lot by bacterial action. The rest is either hauled away or stored in piles. During the first 6 months of 1969 when nearly all runoff occurred, less than 5% of the BOD produced by livestock in the SDSU animal nutrition unit was actually carried away with runoff. Considering the entire year, an estimated 1% would have been removed by runoff.

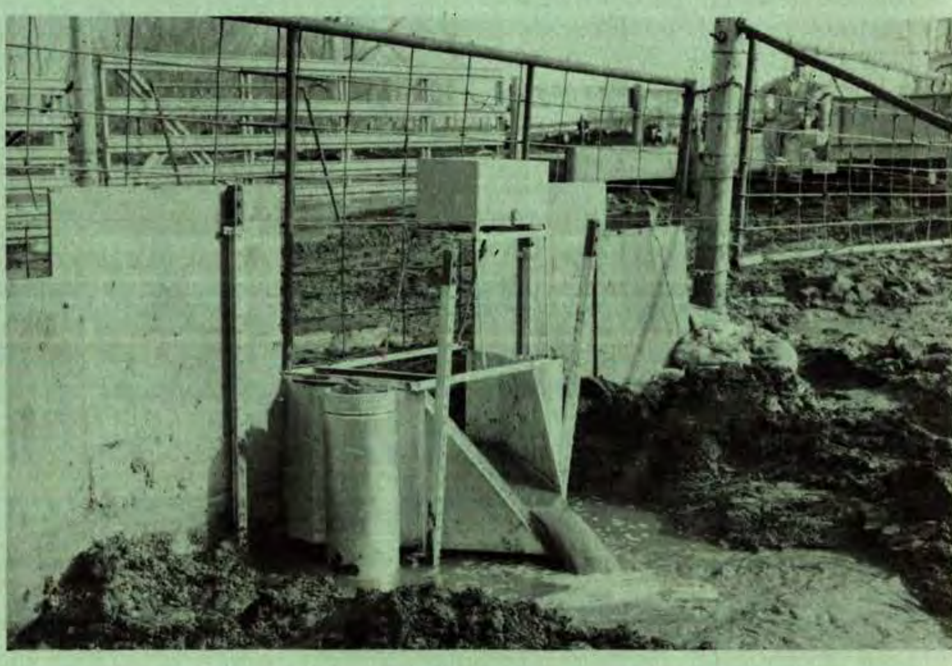
CONTROL OF POLLUTION

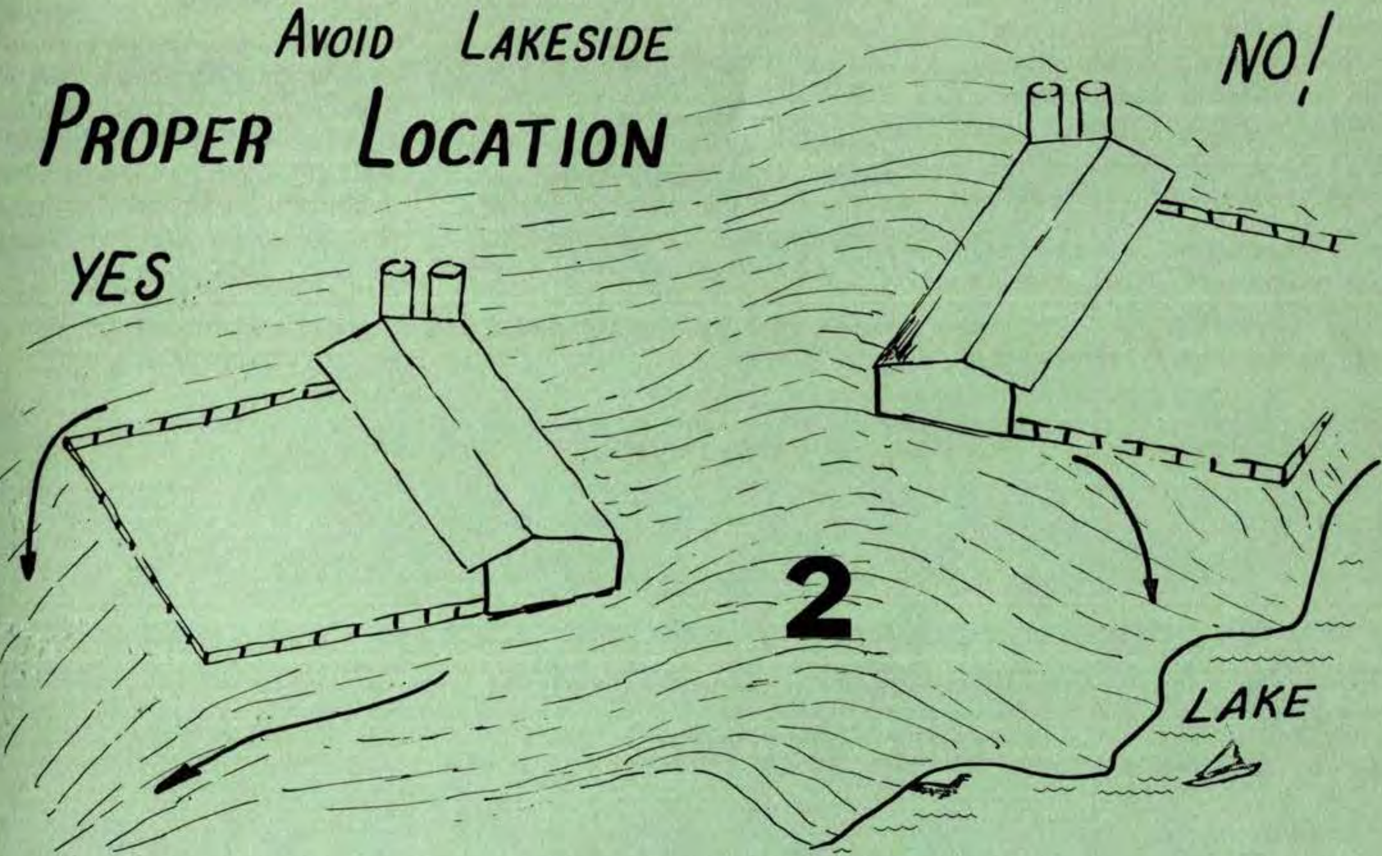
Consolidation. Because runoff volume is closely related to runoff area, increasing animal density (more animals in the same area) does not proportionally increase the pollution potential per animal. Naturally, there are limits to this solution. (See drawings "Possible Pollution Solutions—1").

Location. Perhaps 95% of pollution problems associated with feedlots have to do in some manner with location. Considering water pollution, certain locations are *taboo.* Lakeside locations without extensive runoff control measures are a double hazard: solids from the lot tend to fill the lake; nutrients carried with runoff stimulate nuisance algae growths. As of now, expansion of lakeside livestock operations should be considered advisable only if extensive (and probably expensive) runoff control facilities are part of the expansion plans. The same applies to rivers and streams. Water pollution can often be averted by keeping an adequate distance between lot and stream. "Adequate distance" varies depending upon soil type, slope and drainage characteristics. Locations a quarter to a half mile from a stream *may* be adequate if runoff flows over comparatively flat areas. Air pollution complaints (odors) which result when livestock operations are located near a community may be lessened if

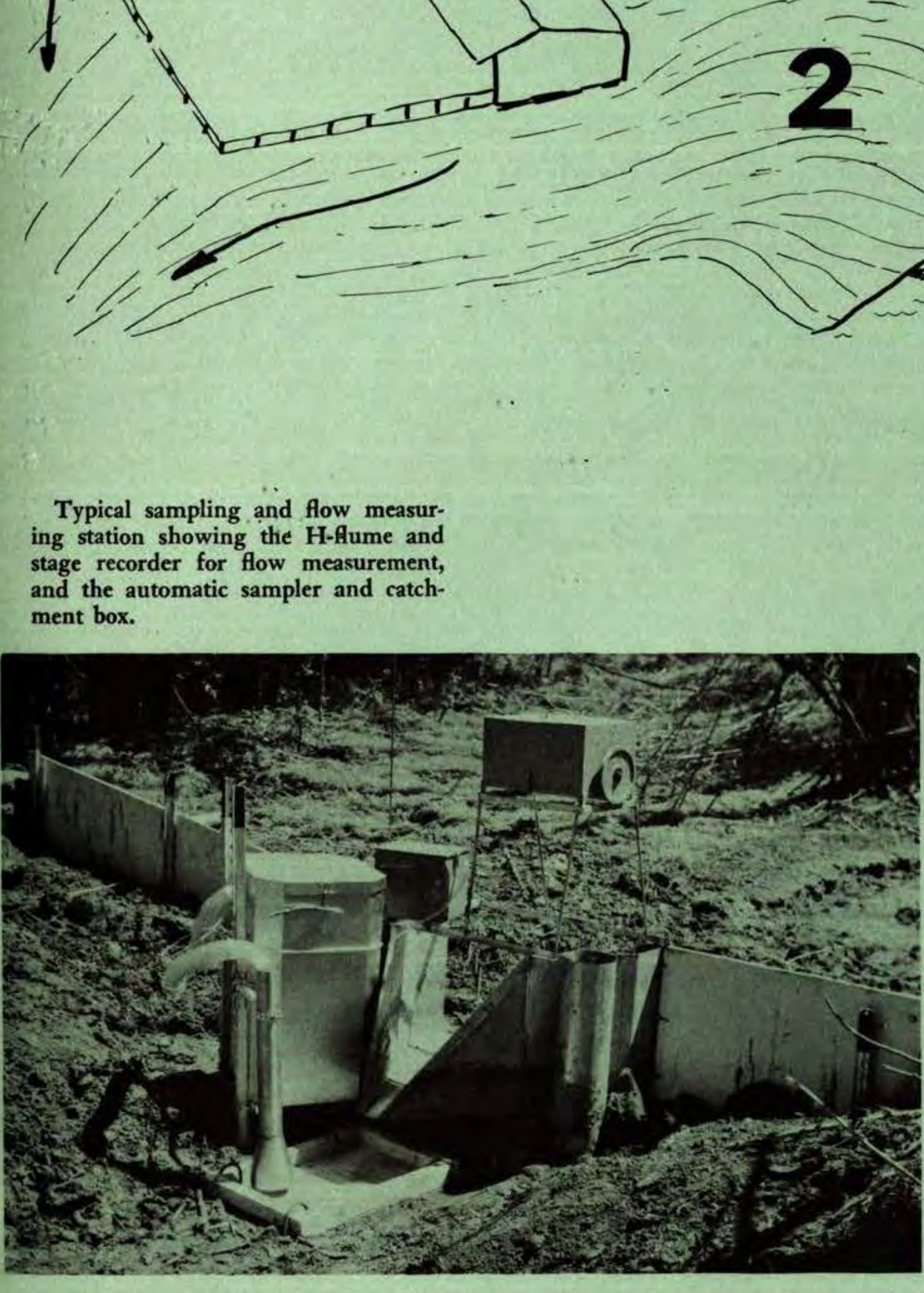


Flow measuring and sampling station during the 1969 spring runoff. Note the similarity in color of the runoff and the solids.





Typical sampling and flow measuring station showing the H-flume and stage recorder for flow measurement, and the automatic sampler and catchment box.



zoning authority granted by the state legislature to cities for areas within 3 miles of boundaries is used. (See "Possible Pollution Solutions" 2 and 3).

Diversion. All "foreign" water—from adjacent land, farmstead, roof drainage, for examples—should be diverted to avoid contact with manure-laden areas. Diversion canals and roof gutters have several benefits: better environment for animals, reduction in odor, marked reduction in volume of concentrated runoff that is the cause of the water pollution. (See "Possible Pollution Solutions" 4).

Terraces. Even after the volume of runoff has been reduced as much as possible, some livestock operations may need additional facilities to eliminate pollution problems. Research so far offers a hint of practical, economical solutions for South Dakota conditions. Measurements taken at one of the feedlot experiments showed 24 days of rainfall (about 10 inches) from mid-April until the end of June. Feedlot runoff occurred on 13 days during this period. But because it flowed through

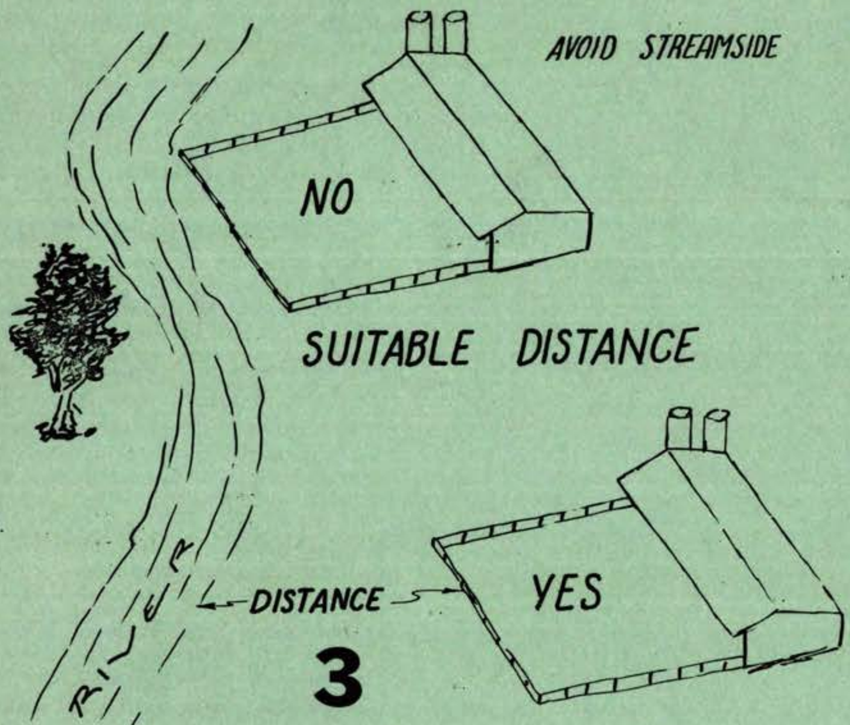
(Continued, next page)

a ditch with a minimum slope and over some agricultural land, the runoff reached a point a half mile away on only two occasions. At other times, runoff percolated into the soil. Investigators imply from this experience that terraces constructed to receive feedlot runoff would probably be sufficient for pollution control in many locations in South Dakota. (See "Possible Pollution Solutions" 5).

Lagoons. A lagoon, to collect all feedlot drainage, would provide treatment through sedimentation and stabilization. However, the high strength wastes may soon turn septic and odorous. Prompt removal of the water for irrigation might avoid odor problems but provisions for periodic sediment removal must also be a consideration. South Dakota's somewhat lower temperature average may adversely affect the necessary bacterial action in a lagoon. (See "Possible Pollution Solutions" No. 6).

COST SHARING

A plan for federal sharing of costs of construction of facilities to intercept runoff and divert feedlot wastes as well as for lagoons for pollution control has been added to the 1970 Agricultural Conservation Program. This program (I-1) includes federal cost-sharing of approved construction up to 80%. Information and technical assistance is available from the ASCS, SCS, or your county Extension agent.□



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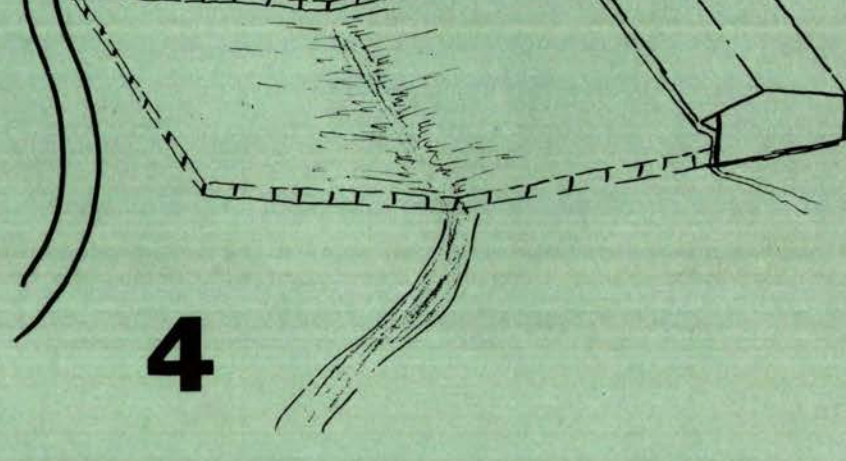

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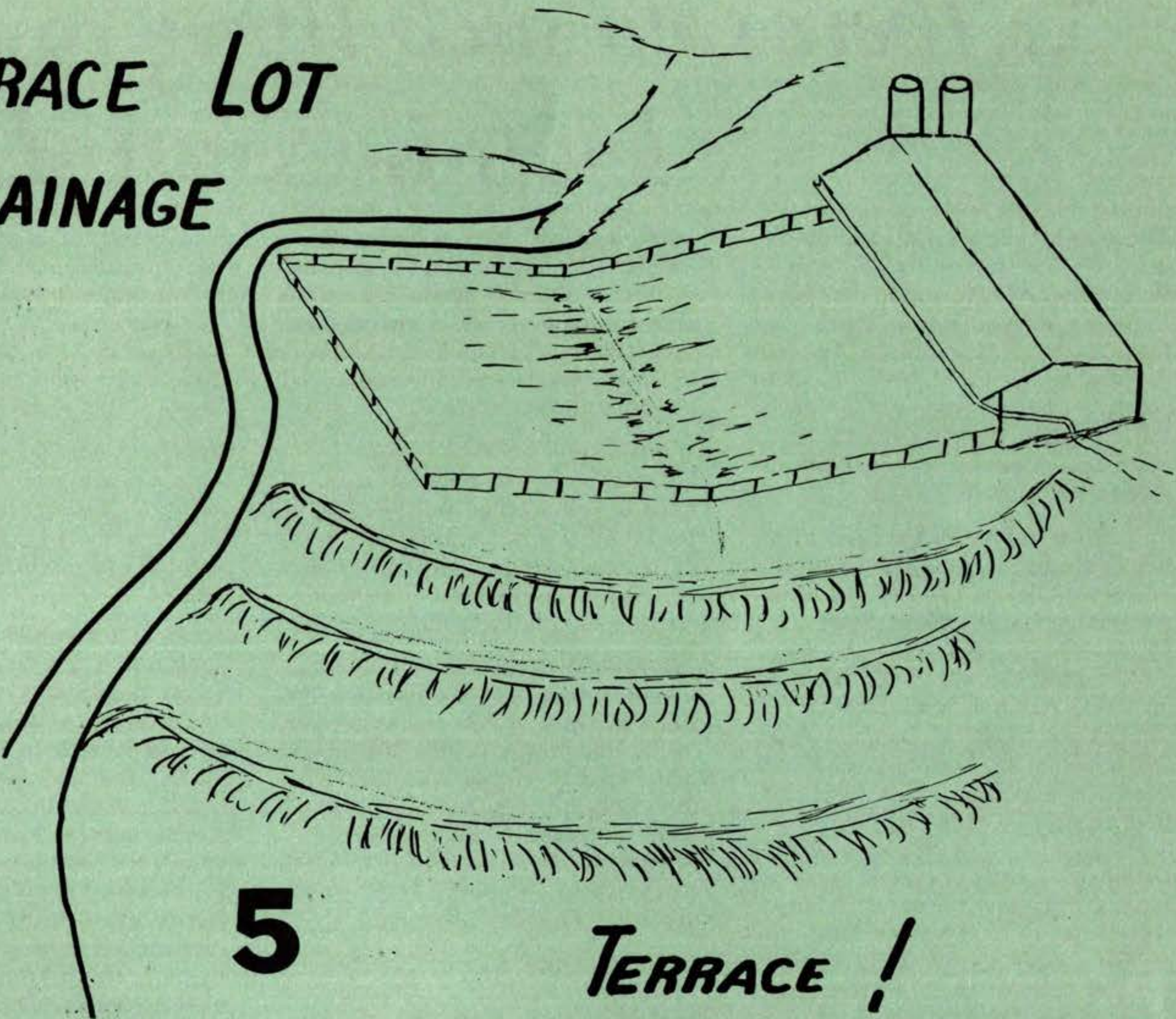
TERRACE LOT DRAINAGE



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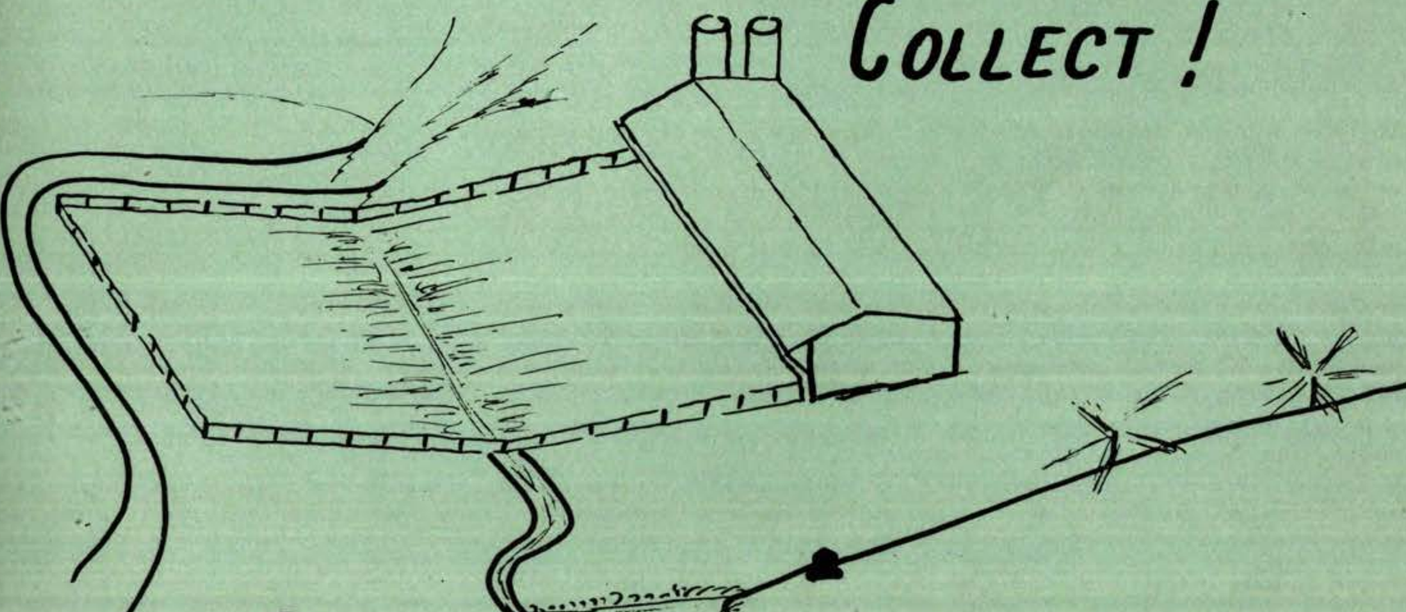
TERRACE!

COLLECT!



6

IRRIGATE!

"... there's no such thing as allowa levels in South Dakota

Those residents of South Dakota in A.D. 2000 won't be singing anything like the current tune that goes ". . . be glad you live in South Dakota-a-a. . ." unless those of us now on the scene are foresighted enough to consider total environment in which we live rather than just the state's immediate capacity for food and income production.

To further emphasize the need to act together, starting now, to forestall intolerable degradation of our environment, a South Dakota State University professor points out that a baby born this year will still be in his 20's as much of South Dakota declines into a virtual wasteland—if soil erosion and deterioration of our lakes and streams is permitted to continue unabated. "The fact that survival is not presently threatened in South Dakota may lull us into a sense of false security as far as our environment is concerned," says John G. Nickum, assistant professor in SDSU's Department of Wildlife and Fisheries Sciences. "Poor soil conservation practices on our watersheds are killing our lakes and streams, primarily by filling them with silt." The professor was one of the speakers at last month's symposium on pollution held at SDSU.

Dr. Nickum pictures the possibility of a South Dakota in A.D. 2000 with only three or four natural lakes, and a few dirty, temporary streams that flow briefly after heavy rains or snow melts. Marshes would be where there are now lakes, dryland in place of present marshes, and eroded wastelands instead of the now-productive fields and pastures. He adds that along with the silt resulting from poor soil conservation practices, excess plant nutrients, animal wastes, and biocides are washed in—further speeding the death process of our lakes and streams.

Picture Now Not Grim

"Currently, the picture is not so grim," continues Dr. Nickum, "as South Dakota apparently is not over-populated, it doesn't have widespread industrial pollution, and its skies are still blue. With the possible exception of unforeseen effects of insecticides, fungicides, or herbicides, our activities in South Dakota seem to pose no real threat to our survival.

"Fortunately, we have a choice—although it has to be made soon; it must be followed universally with no backsliding; it has to become a part of daily living, not just a one-shot effort; and it can't become just a temporary crusade of only the young."

The margin of balance is so delicate, however, that only a comparatively small increase of detrimental factors could shove us in a downward direction which would become increasingly more difficult to halt. South Dakota's lakes and streams are very fragile ecosystems. Few lakes or streams in the entire world are more vulnerable to pollution, Dr. Nickum states.

"Lakes and streams are born, live and die," he explains, "but what we do affects the rate at which they die. What we understand now about these processes must be used to relate abatement measures with different characteristics for each body of water.

"As greater amounts of nutrients are carried into lakes in dissolved or suspended form, higher nutrient concentrations result and the lake becomes over-productive. In other words, slimy, smelly algae blooms develop. If the input of nutrients is low, however, a lake may remain clear and clean—and useful—for centuries.

Life and Death of a Lake

"Silt and nutrient inflows not only increase lake productivity, they also cause lakes to fill in rapidly. All lakes eventually fill in, change to marshes, and finally become dry land. The rate at which a lake dies is obviously related to how much material is washed into it and the amount of aquatic plant and animal remains which settle on its bottom. Activities on the watershed, and the nature of the watershed, determine the quantity and quality of material entering each lake, and therefore, determine the length of each lake's life.

"South Dakota lakes, by nature, are highly productive and shallow so that addition of material which increases their productivity or decreases their volume will produce disastrous results."

Streams in South Dakota suffer from some of the same problems as the lakes. Slow flow rates throughout most of the year cause our streams to be very vulnerable to pollution. When silt enters streams it produces turbid conditions shutting out light from the stream bottom. Plants which formerly supplied a food base for the stream are deprived of light and die, or are buried alive. Small animal life also dies and the stream becomes populated by only a few of the hardiest fish. Silt may not physically destroy a stream, but it can make it a virtual biologic desert.

Is Happening Here

Dr. Nickum declares that we are unable to put a total figure on agriculture's contribution to South Dakota water pollution. He believes it is not necessary to know the exact totals—especially before we start doing something. We do know, he says, that where good soil conservation has not been practiced our lakes and streams are dead, or nearly so. Information obtained about Lake Herman and Enemy Swim Lake illustrate some of the things that happen.

"Most of Lake Herman's watershed is cultivated cropland, while very little of Enemy Swim's watershed is cultivated. Lakeshore cabin development is essentially similar around both lakes. The two lakes appear to have been reasonably similar prior to cultivation on their watersheds. Today, total

ble pollution lakes and streams..."

dissolved nutrients are approximately twice as high in Lake Herman as in Enemy Swim. Total phosphorus is up 10 times higher in Lake Herman, sometimes exceeding 3 parts per million (most U. S. lakes contain less than 0.1 p.p.m. phosphorus). Maximum algae blooms are almost 100 times more dense in Lake Herman. About 7 feet of silt and muck cover Lake Hermans' bottom, reducing its volume to a point where winterkill of fish is common. Enemy Swim has never had a fish winterkill. Enemy Swim is a highly productive lake on the basis of national averages, but it is practically sterile in comparison to Lake Herman. Enemy Swim will certainly see the year 2000, but I wouldn't risk my money on Lake Herman (even with dredging) unless good soil conservation is practiced on its watershed."

Silt Not Only Villain

Silt, with its tremendous nutrient content, is the main but not only pollutant of South Dakota lakes, according to the professor. He says that nitrogen fertilizers sometimes leach into ground waters, only to reappear in lakes and streams, adding unneeded fertility. Where feedlots and barnyards are improperly located, animal wastes add fertility and consume oxygen needed by aquatic life in the ecosystem. Animals trample stream banks and bottoms adding more silt and further reducing aquatic plant and animal life.

Dr. Nickum believes that if we but foresee the effects of our present activities—and plenty of examples are around—that farmers, ranchers, businessmen, industrialists, researchers and educators, politicians and governmental officials, and the general public, working together can forestall the degradation of our environment and still provide the productive capacity we need.

"We must realize," he states, "that due to their natural characteristics there is no such thing as allowable pollution levels in South Dakota lakes and streams." □

Soybean Research To Reduce Pollution?

A successful search for a growth inhibitor in soybeans may make a contribution to reducing pollution.

Scientists have known for a fairly long time that something in raw soybeans depresses animal growth rates. But so far that "something" hasn't been identified sufficiently to let research take a good hard look at it.

Last month under a $30,000 research allotment from the National Science Foundation covering a 2-year period, Agricultural Experiment Station scientists began a new project attempting to find out more about the growth inhibitors in soybeans. Principal investigator is David J. Schingoethe and co-investigator is John G. Parsons. Both are assistant professors in the Dairy Science Department.

Objectives of the research are to

Now HEAR This!

There's been a lot of talk about apathy of the general public regarding pollution. Depite all of the wide publicity and expressions about dangers of all forms of pollution, so the story goes, many individuals couldn't care less and apparently are not interested.

Perhaps they are overwhelmed.

Or, it may not be lack of interest, it may be that people as individuals are having trouble finding out just what they can do and where they can begin to do something about the wide-ranging problems of pollution.

For instance:
The student Mechanized Ag Club at South Dakota State University in early March kicked off a campaign against noise pollution—doing their thing to help in an effort to convince farmers that noisy agricultural machinery could cause permanent hearing damage (see South Dakota *Farm & Home Research*, Winter 1970 issue).

The club based much of its campaign on Agricultural Experiment Station research which showed that many agricultural machines operate at noise levels dangerous to hearing. One way

Feedlot Pollution: A Solvable Problem?

It's barely possible that feedlot animal wastes won't be the surface water pollution threat as earlier anticipated in South Dakota.

In the somewhat dreary and clouded picture of impending pollution problems, a slight speck of light may be seen in preliminary appraisals of research underway at South Dakota State University.

For instance:

- Surface drainage and topography may dissipate livestock waste runoff more than generally realized.
- Good land management might replace some rather sophisticated — and expensive — waste treatment facilities.
- There's a time factor in pollution over which man may exercise control.
- South Dakota's position gives it some lead time — but not a comfortable amount — in attacking pollution problems before they become disastrous.

It doesn't mean pollution control can be disregarded, that no problem exists. There are problems, large ones, connected with one of South Dakota's major industries, feedlot production of meat. That's one reason representatives of civil engineering, animal science and agricultural engineering departments have combined efforts under the Water Resources Institute to find out more about potential pollution from livestock sources. This research aims at finding out more about pollution from the standpoint of what can and should be done, when it should be done, and how best it can be accomplished.

Spring Runoff Records

This project has and will continue to provide some of the needed answers. For example:

The record 1969 spring snow and

isolate, characterize both chemically and physically, and determine the mechanism by which the "something" in soybeans depresses animal growth rates.

Dr. Schingoethe explains that currently 20% of the soybean protein is discarded as a waste product during the preparation of soy-protein concentrates and soy-protein isolates because methods of detoxifying the whey fraction have not been developed. He adds that the growth inhibitors remain primarily in the soybean whey fraction. Actually, these growth depressing factors can be destroyed or inactivated by heat. But such treatment destroys the solubility properties of the meal which is desired in many feed and food products.

After the growth inhibitor—or inhibitors—is identified, new methods can be developed to remove or inactivate them and use much of the soybean whey fraction that is presently being discarded. This would help eliminate a protein loss and at the same time reduce a waste source that in some cases becomes a serious pollution problem. ☐

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to prevent this damage—fight noise pollution—was a do-it-yourself method of soundproofing the inside of a tractor cab with accoustical foam materials. Another way, the research revealed, was use of lightweight, low cost acoustical earmuffs.

Club members decided to obtain some of the earmuffs and make them available to interested farmers at a price that would include a slight profit to be used for conducting additional farm safety programs in high schools and other places.

The club ordered about two dozen earmuffs as a starter. The first mail after the club's announcement brought 18 letters wanting earmuffs or more information. By the end of the first week inquiries totaled above 200 from five states.

Harvey G. Young, assistant professor of agricultural engineering and club adviser, said an order for more earmuffs went out immediately. During Easter vacation, many club members went around in their communities telling farmers about the potential dangers from "unwanted sound"—noise. They also carried along some of the "ear protectors."

"We were really happily surprised at the response," said Young. "The nice double-barreled thing about it is that club members recognized a need and and then set out to do something constructive about it, while many persons interested in protecting their hearing found out about a way to do it and reacted. I guess both groups could be classed as pollution fighters in their own way." ☐

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rainfall runoff from SDSU experimental beef and dairy cattle feedlots provided data which led a civil engineering graduate student to suggest that emphasis on good land management aimed at pollution prevention might be more appropriate rather than too much emphasis on sophisticated and expensive waste treatment and control methods.

Keep Farmer Farming

"Let's not aim at making the farmer feedlot operator a sewage treatment operator, let's keep him a farmer but provide him with know-how to minimize the possibility of pollution with a method he can afford and that requires very little maintenance," suggested Paul Thormodsgard, former graduate student, now a sanitary engineering officer in the U. S. Army Medical Corps. "We have considerable technical know-how to provide treatment facilities for reducing the pollution potential of feedlot wastes but this won't be of much help if it saddles the farmer with a complicated system that takes a lot of his time and most of his money to operate."

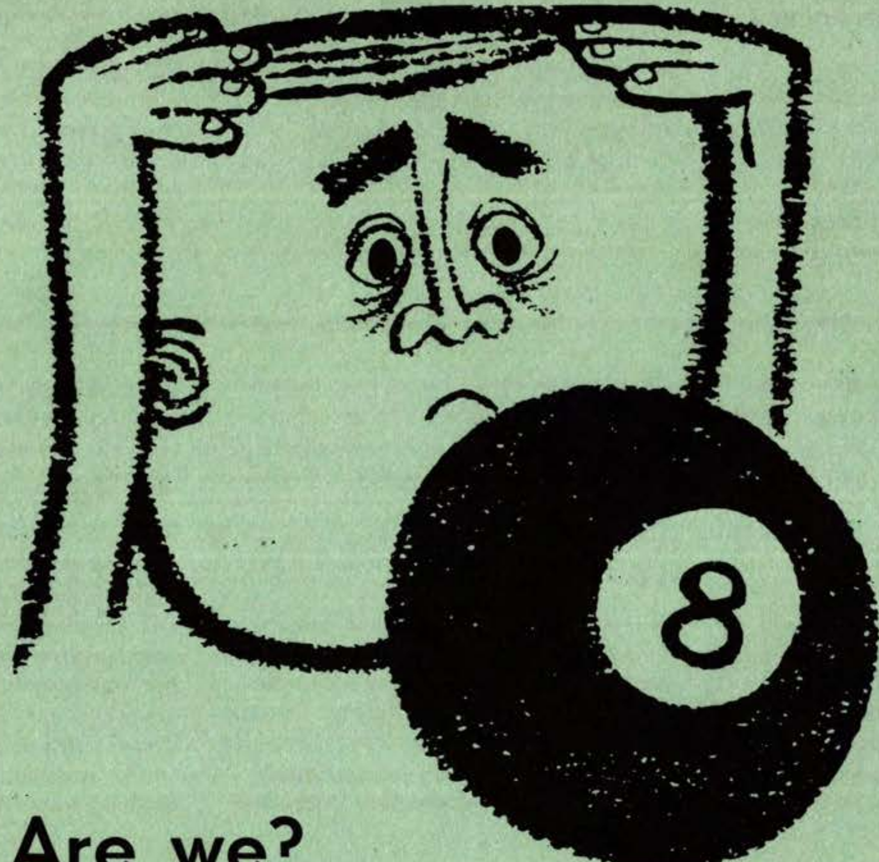
Thormodsgard should know. His SDSU degree in civil engineering specializing in sanitation engineering provided him with some of the technical know-how. The fact he was born and raised on a livestock farm near Alcester gives him the view from a farmer's standpoint.

His research was part of a several-year continuing study aimed at providing help to the feedlot operator as well as to governmental agencies in establishing feedlot pollution control guidelines or standards.

First South Dakota Data

Thormodsgard's measurements of runoff from snow provide some of the first data of this type available in South Dakota. He found that feedlot waste runoff as a result of snow melt had been largely dissipated by a terrace-like ditch and a plowed field which served to break the "link" between one of the experimental feedlots and a stream. However, later heavy rains restored the "link." The plowed field in this case provided a key or clue in the possible use of land management practices for surface water pollution control.

Feedlot runoff, Thormodsgard found, was usually highly concentrated and under these conditions if introduced into a receiving stream can have adverse effects from solid matter or by reducing the oxygen concentration in the water. However, in times of flood, he pointed out, the great volume of water may have a diluting effect to help maintain satisfactory downstream water quality. He noted that runoff from a feedlot is related to type of precipitation – rain or snow – and could be "modified with time" by use of retention ponds or in some cases terraces such as in a plowed field. ☐



Are we? Pollution-wise

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